TECHNOLOGY TRANSFER IN NEW MEXICO

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SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

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TECHNOLOGY TRANSFER IN NEW MEXICO

TUESDAY, AUGUST 18, 1981

U.S. SENATE,
COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Albuquerque, N. Mex.

The subcommittee met at 10:15 a.m. in the Albuquerque Convention Center, Hon. Harrison H. Schmitt (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR SCHMITT

Senator SCHMITT. Ladies and gentlemen, if we could have your attention. We have a tight schedule and we'll have to try to move fairly quickly through it.

Today's hearing is intended to examine one of the most critical and frustrating dilemmas facing our country, that is, how to counter the erosion of our preeminence in the successful commercialization of new technology without resorting to restrictive trade policies and other policies that are counter to our basic free enterprise philosophy.

The hearing is also a continuation of a broad series of hearings where I am attempting, and the subcommittee is attempting, to tap the expertise and background of the scientific, technical, and business communities of New Mexico in order to assist in the formulation of broad national policies, as well as policies which affect the future use of technology in this State.

There is a spreading realization that the scientific and technological advantages which the Nation enjoyed for much of the post-World War II period can no longer be taken for granted. This shift is particularly significant since our critical edge in national defense, economic competitiveness, or general well-being is increasingly dependent on advantages in science and technology, and our abilities to transfer these advantages into new and superior products and services. Of course, we should also always keep in the back of our minds the importance of the science and technology base of this country in preserving world peace and the security of the free world.

Currently, this country invests $69 billion in research and development, of which about half, $34 billion, are Federal funds. Now, one must take those numbers with a grain of salt. It's very difficult to put your arms around the actual investment that we make or whether that investment is in for hands on research and development or whether it's for administrative purposes.

I should mention here, also, that the subcommittee is in the process of an extended effort to try to itemize and analyze the R. & D. budget of the Federal Government, and at some future time hopefully we can expand that, then, into the public sector and private sector. The science and technology budgets that we are attempting to develop will be of great help in congressional activities of a variety of kinds.

The Federal funds, or $34 billion, are invested in our universities, small businesses, Government laboratories, research institutes, businesses, and industries. However, when the private sector invests its own funds in research technology and development, it is usually with the intention of offering new or improved goods or services into the economy. This is seldom the case when the R. & D. investment is made by the Federal Government. Thus, the practical utilization of much of our investment in research and development is being left largely to chance, although the chance of the marketplaces sometimes is a very good guide, so long as we let it operate. I don't think that this is a responsible use of taxpayers' money, however, to leave this to chance or, for that matter, is it necessary.

The present administration is emphasizing incentives for those willing to take the risks of innovation and commercialization, while reducing the direct Government participation. This approach appears in the form of tax credits for investment that we see in the recently passed tax bill and reduction in regulatory burdens that are being undertaken not only by the Vice President in his group, but also by the Congress.

Along these lines, an area of special interest to me is that of patent rights to inventions which result from federally funded research and development. The value of these patents is largely lost unless the resulting discoveries and inventions are commercialized. This result can best be achieved if those who perform the research and development have the opportunity and the incentive to effect the commercialization, which is not the case today in most work done by the Federal Government outside of that of the Defense Department.

However, the Government's policy has generally been to retain title and rights to those inventions produced under its sponsorship, with the result that while the Government presently holds title to some 28,000 inventions, only about 5 percent of these have been commercialized. Therefore, last month the first of a set of hearings was held on a bill which I have had drafted to provide for uniform policies and procedures throughout the Federal Government for assignment of patent rights to qualified recipients of Federal research and development funds. This bill is being worked out in closer cooperation with the House of Representatives, and we have high hopes that it will become law in this session of Congress.

I was also supportive of efforts to enact the Stevenson-Wydler Act of 1980, which provides a variety of mechanisms to stimulate scientific and technical exchanges and interactions among industries, universities, and the Federal laboratories, and to increase the use of federally funded technological developments by State and local governments. We will hear more today about the progress which is being made under this legislation.

New Mexico is a particularly appropriate site for today's hearing. As I indicated earlier, this is a part of a long series of hearings that do tap the expertise in science and technology that is so inherently a part of the New Mexico scene. Our State has a large concentration of high technology industries and major Federal laboratories, along with active academic research. The Federal Government funds more than a billion dollars of research and development in New Mexico each year.

Incidentally, I hope that all of you will attend and participate in the Showcase for Technology which will be held in Albuquerque October 28 through 30. Following through on a suggestion which I made several months ago, a number of universities and Federal laboratories in our State have worked together to organize this conference and exhibition, which will offer an exciting look at the potential for commercializing the technology which results from this $1 billion-plus of publicly funded research and development. The response and participation by the private sector in this Showcase for Technology have exceeded our expectations. This is the most important national event of the year for those with primary responsibilities for technology acquisition, research and development planning, product planning, product commercialization, and the like.

Our hearing today will address specific efforts in technology transfer by the national laboratories, universities, and industries in New Mexico. The purposes are to understand better how the transfer process works today and the obstacles which need to be overcome in that process.

The insight gained should help the committee in improving the productivity and economic competitiveness of the Nation through whatever appropriate legislation and hearings may be necessary.

We have Secretary Malcolm Baldrige here today. Mr. Secretary, would you like to join me up here for the time that you have? Are you trying now to get out of here a little bit earlier than we had originally planned?

STATEMENT OF HON. MALCOLM BALDRIGE, SECRETARY OF COMMERCE

Secretary BALDRIGE. Anything you say, Senator. I'm in your hands.

Senator SCHMITT. We're not interfering in your participating in a rodeo, are we?

Secretary BALDRIGE. Well, I haven't had enough chance to practice lately, so I wouldn't worry about it.

Senator SCHMITT. Mr. Secretary, it's great to see you. Why don't we give you a little bit more flexibility. We have a statement, I believe, that is a fairly detailed analysis of the Stevenson-Wydler Act and the current situation with respect to that act. If you would like to make an opening statement, I'm sure that we could have that for the record now, then you can participate as you see fit.

By the way, I should make sure everybody understands that you're almost a New Mexican. You have a ranch near Corona, as I recall, and often make trips out here to make sure that some of our good New Mexican friends are operating that ranch properly.

Secretary BALDRIGE. Well, I don't have to worry about that; they sure do a good job of that. New Mexico is my second home, and I love to come out here.

I think the subject of these hearings is vital to this country's interests. Increased technology transfer is a major part of increasing our productivity, we all know that. Over the last 20 or 30 years, the United States began to lose its leadership role in some areas. There have been many reasons for that, but we can regain what we have lost.

Inflation has taken a heavy toll. Private sector investment in research and development has not been what it should have been. The oil crises have had a disruptive influence on our economy and our productivity. Other countries, and this is going to be a serious problem for us in the next decade, heavily subsidize those areas where they desire to be world leaders, particularly in exports.

For example, Japan has targeted some of their companies, like Fujitsu, to take the world leadership role away from IBM by 1990 or 2000. Japan is doing this by providing heavy government subsidies. We do not subsidize our industries; we depend on private initiative. We have to regain our competitive edge if we are going to keep our world leadership areas. We must keep them, if our economy is to grow.

The Senator's initiative is one that we all welcome in Washington. I'll guarantee you we listen to Senator Schmitt when he talks on this because of his tremendous experience and the just plain hard work he puts in this area. That's why I was delighted to stop in today. I think the area of technology transfer that we're addressing today is a tremendously important one. Increased technology transfer is vital if our industries are to retool and begin to produce new products.

I think, Senator, that is essentially what I want to say. I want to congratulate you on your efforts. I want to give you my full support for the Showcase that's going to be here later; I'm going to try my best to come down for that. I don't know if I'll be able to come, but I'm certainly 100 percent behind you in your efforts. Nothing is more important for the next 20 years than what you're trying to do here.

Senator SCHMITT. Thank you, Mr. Secretary. New Mexico, as you are well aware, has a tremendous amount of experience and background to contribute to the national scene. We've been involved before, we are involved now, and we all hope to be involved more in the future.

I might ask you a couple of questions for you to make comments on. You mentioned the problems we have with the Japanese and some other countries that have targeted certain industries. They're leaving other things to somebody else or ourselves, but they target, like in the computer industry and previously in automobiles and electronics for the Japanese.

Taking the Japanese specifically, there seem to be two fundamental problems: One is that they have a cultural environment that allows the very close integration of government and industrial activity and between companies, as well as between companies and the government. There's a close integration of people and ideas and planning. That just isn't possible under our current system of law

in this country or even under our current systems of attitudes that we have. Now, that's one issue of how do we compete with a country that is capable of doing that.

Second, the Japanese have essentially an open and free market in the United States, wherefor what we do best we have a closed market in Japan, particularly for agricultural goods, but also for manufactured goods. There again is an artificial advantage that they have over many of our industries.

How do we handle those two things, the cultural disadvantage we're in in a sense or the cultural advantage they have and the trade advantage that they have?

Secretary BALDRIGE. Let me discuss the cultural advantage first. I'm not sure Japan has an advantage. They're making good use of what they have now, but in the long run I think we have the advantage. But there is not doubt that a very homogenous, close-knit country. After World War II they all hung together, being loyal to each other.

If we knock down every trade barrier and every nontariff barrier, it still would be tremendously difficult for an American company to move into the Japanese market in a large way, because the Japanese consumer feels that it's patriotic to buy Japan. They will spend more, usually, for a Japanese article than they will for a U.S. article because of this loyalty.

The Commerce Department is making a dedicated effort to aid our industry in penetrating the Japanese market. I think this effort will pay off in the next 2 years. We have a trade facilitation committee that's attended by one of our Under Secretaries and an equivalent ranking Japanese official, in which we are going to the Japanese and attacking by saying, look, we have a large trade imbalance with your country. This is one of the reasons why we want you, as industrialists, to make it as popular as you can to buy American goods in Japan. In short, we want you to help spread American trade in Japan because it's for your own good. If our trade imbalance gets too much out of whack, you're going to see protective legislation come up in Congress that nobody's going to like. Instead of having a closed trading society, you've got to help open it up because it's a problem indigenous to your country.

We don't know whether we're going to be successful or not, but I guarantee that we are going to bear down hard. We have some indication that they are willing to make some movement there.

In the other area, on the actual kinds of quotas, tariff, nontariff barriers, that is something we are simply going to have to negotiate out by tough trading. We are going to be tough traders in that area. They've outtraded us for too long.

I don't want to take too much time, Senator.

Senator SCHMITT. Go ahead, because it's an important part of the picture.

Secretary BALDRIGE. For example, take the automobile and steel industries, and now we're seeing it with the telecommunications and computer industry. When they want to have an industry grow, like their automobile or steel industry, they've done it. First, they protect the industry with tariff barriers. Then they subsidize it by pouring government funds into research and development. By using the two, they have been able to capture the whole of their

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own domestic market. That market is large enough to give them economies of scale. So now all of a sudden this baby they've been protecting has grown up to be a 24-year-old muscle-bound football pro. Then the Japanese will circle the world calling for free trade in that particular industry.

Now, they have done it with automobiles. Their automobile industry had that protection when it was growing up and now they're crying for open markets. The same thing for their steel market. Once they learn how to do it, well, then, whammo, they want open markets around the world.

We're seeing that right now beginning in the computer and telecommunications area. Just at the same time when we're slamming around our telecommunications people, suing ATT, trying to break up everything that we got going in this country, Japanese are doing exactly the reverse. They are force-feeding R. & D. at government expense to their Fujitsus and Hitachis and so forth to enable them to get a size where they can compete with IBM and ATT worldwide, and then they'll call for free world trade. Our biggest problem over the next 10 years, will be to surmount that. We will have to trade the inequities out.

Senator SCHMITT. I think you're right. We're just going to have to become far better traders than we have been. And I think the multilateral trade agreement under the last administration is a good example of that, where we left our market essentially open—and I'm not saying they shouldn't be open—but we allowed them to maintain closure in particularly agricultural markets in Japan and Europe also. And even though we exported almost $50 billion of agricultural goods last year, that's only a fraction of what we are capable of exporting, and particularly where the Japanese consumer has indicated strongly they would like to have access to beef, access to citrus fruits, access to lower cost wheat and feed grains, and so forth.

So we have a lot to gain. I take it by your remarks the administration fully recognizes this and understands why there's growing pressure in the Congress for using the leverage of potential restrictions to get the Japanese to recognize where their best interests lie in the future.

Secretary BALDRIGE. I'd like to have a couple of the New Mexico cattle traders do our negotiations. They would work it out.

Senator SCHMITT. We used to have the reputation for being tough traders throughout the world, and somehow or another, at least since World War II, we've lost that, and maybe we can regain it. I certainly know we have the people to do it, but we haven't set up the mechanism.

Secretary BALDRIGE. We've got the people, that's for sure.

[The statement follows:]

STATEMENT OF HON. MALCOLM BALDRIGE, SECRETARY OF COMMERCE

Mr. Chairman and Members of the Subcommittee: I am pleased to be in New Mexico today to discuss the transfer of Federal technology to State and local governments and to the private sector. Specifically, I would like to address the Department of Commerce's implementation of the technology transfer provisions of the Stevenson-Wydler Technology Innovation Act of 1980. Last year, the Senate Subcommittee on Science, Technology and Space and particularly you, Mr. Chairman, played an instrumental role in the passage and signing into law of that Act.

The people of New Mexico and the rest of our Nation will benefit from your longstanding concern for increasing the rate of technological innovation in the United States. You have been at the forefront of recognizing how improved Federal technology transfer can increase technological innovation. I congratulate you for the steps you have taken.

In Section 2 of the Stevenson-Wydler Act, Congress found that there was a need for a strong national policy supporting domestic technology transfer. Congress found that State and local governments and private industry needed improved access to the science and technology resources of the Federal Government. The Federal laboratories and others who perform research and development paid for by Federal funds frequently provide the Federal Government with scientific and technological developments of potential use to State and local governments and to private industry. A major feature of the Stevenson-Wydler Act is Section 11 which deals with improving the rate of technology transfer from the Federal Government to those sectors.

The Act requires every Federal laboratory to establish an Office of Research and Technological Applications to provide and disseminate information on Federally-owned or originated products, processes and services having potential application to State and local governments and to private industry. The National Bureau of Standards has already fully complied with the Act's mandate by restructuring its extensive technology transfer activities and by establishing its office. I have directed the other laboratories in the Department to complete the process of establishing their offices as quickly as possible.

The Act requires each agency having a Federal lab to spend at least one-half of one percent of the agency's research and development budget on technology transfer. We are in the process of confirming that all agencies within Commerce which have laboratories currently expend at least this amount on technology transfer.

Since 1950, dissemination of technical information has been a primary mission of the Department of Commerce. In 1950, Congress enacted a law which directed the Secretary of Commerce to establish and maintain within the Department of Commerce a clearinghouse to collect and disseminate, on a self-sustaining basis, scientific, technical and engineering information. Since September 1970, the National Technical Information Service (NTIS) has been that clearinghouse. NTIS will be participating in Albuquerque's "Showcase for Technology" this October.

NTIS has four major programs. Its Information Clearinghouse Program sells Government-prepared or sponsored technological, scientific, economic, business and engineering reports and Government-generated computer processed data files.

A Government Inventions Program provides for the collection and announcement of government-owned inventions available for licensing, the filing of patent applications on selected inventions in foreign countries and the promotion of the commercial application of government inventions.

A Science Information Exchange Program provides for the dissemination of information of maximum value on research in progress to improve the management and application of our nation's resources for science and technology.

NTIS conducts a Technology Transfer Program designed to encourage industrial innovation. The goal of this program is to improve the economic health and growth of U.S. firms as well as increase the world competitive position of American industry.

The Stevenson-Wydler Act established a Center for the Utilization of Federal Technology (CUFT) within Commerce with a number of assigned activities ranging from serving as an information clearinghouse to giving financial assistance to Federal laboratories to enable them to provide technical assistance to State and local governments upon their request. To the extent that some specified CUFT activities require the outlay of appropriated funds, we will not be able to perform them. This does not reflect on the merit of the activities, rather we just cannot afford them.

Improved technology transfer is important to our economic recovery. We intend to transfer as much information as possible as quickly as is possible. When transfer is incidental to our research and development work and where it can be done without direct appropriations, recipients will not be charged. For technology transfer that is not incidental to research and development work and which requires funding, those who want the information will required to pay the transfer costs through user fees.

To improve the flow of knowledge from Federal laboratories and research and development centers to industry and to State and local governments, I have directed NTIS to perform as part of its Techology Transfer Program those CUFT activities which can be conducted on a self-sustaining basis. NTIS will be able to do much on this basis.

For example, the Stevenson-Wydler Act requires the Office of Research and Technology Applications in each Federal Laboratory to prepare an assessment of every research and development project at the laboratory having potential for State or local government or industrial application. NTIS will collect, publish and actively market those assessments. NTIS is working with the Federal Laboratory Consortium to design a standardized assessment format and to establish procedures for the efficient collection and dissemination of assessments. Assessments will be made available through special publications; on-line data processing services; and other innovative techniques.

Also in response to Stevenson-Wydler, NTIS in the latter part of 1980 launched a new interdisciplinary biweekly newsletter entitled "Information for Innovators." Each issue highlights eight to ten significant technology developments and analyzes their practical significance.

The existing NTIS "tech notes" program widely distributes summaries of new applications for technology developed by Federal agencies and their contractors. This program will be greatly enlarged to assure coverage of all Federal laboratories that wish to participate.

In cooperation with the Patent and Trademark Office, NTIS will start two foreign patent information services during Fiscal Year 1982 to alert U.S. industry to foreign competition. The first will publish one page abstracts of foreign inventions with background and references, grouped by SIC classification rather than by technical discipline. The other will analyze recent patents in specific fast moving fields, such as robotics or machine tools, which affect many diverse industries. NTIS has also initiated a new program to disseminate technical information resulting from research and development funded by foreign governments and industries. This program translates, indexes and disseminates important abstracts or documents not available in English. The program is designed to acquire 30,000 foreign technical reports annually and make available to U.S. business and professional interests 30,000 translated abstracts and 1,000 seleted evaluated report summaries of the most promising new foreign technology.

As NTIS identifies additional activities which can be conducted on a self-supporting basis, we will consider adding them to our program of stimulating the utilization of Federal technology.

In concluding my remarks, I would like to mention a very special arrangement we have for the people of New Mexico. NTIS has entered into a cooperative arrangement with the Technology Applications Center at the University of New Mexico at Albuquerque. NTIS makes available its computerized data bank to the Center at no charge for the Center's use in helping to transfer Government technology to New Mexico industry.

Thank you inviting me here today.

Senator SCHMITT. Let's move forward, then, with our first witness, Mr. James Williams, who is Assistant Director of Planning and Analysis, Los Alamos National Laboratory.

Jim, it's good to see you, and please proceed with your statement. If you wish to summarize, your entire statement would be included in the record, and I would encourage you to summarize, if you will, because we're running on a tight schedule this morning.

STATEMENT OF JAMES WILLIAMS, ASSISTANT DIRECTOR, PLANNING AND ANALYSIS, LOS ALAMOS NATIONAL LABORATORY

Mr. WILLIAMS. Thank you, Senator.

As you know, I'm speaking for Dr. Eugene Stark. His full statement will be submitted for the record. Dr. Stark is Chairman of the Federal Laboratory Consortium, and he is also the Technology Transfer Officer for Los Alamos National Laboratory. I'm filling in for him today.

It's indeed a pleasure to testify to your committee on an issue of importance to the State and the Nation. I'm sure we all agree that the productivity of this Nation depends on our ability to transfer innovative new technologies to practical use in the consumer marketplace. This testimony covers two topics. It includes observations

on mechanisms of technology transfer with a couple of examples and also discussion of the role that the Federal Laboratory Consortium plays in technology transfer.

The Federal laboratories in New Mexico have a history of involvement in technology transfer. There are four laboratories in New Mexico who are involved in technology transfer. They're all members of the Federal Laboratory Consortium, and each of them has an individual who is the contact for that laboratory to interact with others around the Nation in technology transfer. These labs include Sandia, Los Alamos, the Army's physical sciences lab, and the Air Force lab.

The technology transfer process takes many forms, but the main idea is to get people and ideas together. Where an industry has a problem, you'd like to get an innovative person together with people in that industry to solve the problem. In the case of small business, it's particularly a problem because they're so busy trying to make a profit they don't necessarily have innovative people or access to innovative ideas.

The labs and universities are a particularly vital source of science and technology and innovative people that can serve that purpose, if you can just get them together with industries which need the ideas. There are many mechanisms for this: Person-to-person interaction in professional societies; cooperative R. & D. ventures where industry and the laboratories get together on something of mutual value; industry supporting R. & D. in the labs—there's not enough of that, and I'll say more about that in a minute; movement of people from a laboratory to go out into industry and actually exploit a new technology. The entrepreneur who really goes out and does it is probably one of the best ways of transmitting technology into practical use in the marketplace. Then there are situations where the laboratories subcontract industry, which is also a mechanism for supporting that kind of technology transfer.

Of course, there are barriers; they're well-known. They have to do with the capability of the user, the technical risk, the economic risk, how do you handle proprietary information? Federal laboratories have to serve the public, everything has to be pretty much open to the public sector. And of course, the question of exclusive licensing or waiver of patent rights becomes a key question. This is where a company can achieve a competitive edge, and unless you can assure that they have that competitive edge, they're not likely to risk their capital in that direction.

Those were just a few of the comments in the testimony to do with the mechanisms of technology transfer as we have experienced them in the laboratory.

The Federal Laboratory Consortium (FLC) is comprised of some 200 Federal laboratories funded by 11 agencies, Federal agencies. They are sponsored by the NSF and are really getting up quite a head of steam in providing broad communication amongst the laboratories, industry, universities, trade associations, and so on.

The primary value to the State of New Mexico of this Consortium is that it provides an efficient network of referrals to technology availability among all of the Federal laboratories, since these people get together, they communicate amongst themselves, and

then interact with potential users of the technology. It also provides this State with access to technology that might be developed at Oak Ridge National Laboratory, for example. The FLC has also established a number of interfaces with innovation groups and local governments, industry trade associations, and so on.

One of the success stories I wanted to mention here has to do with technology transfer conferences. The FLC has worked with various local organizations to conduct conferences that describe the technology to people in that local region. Of course, one such example has already been mentioned, the Technology Showcase to happen in October here. FLC is very significantly involved in that and there are a number of these beginning to happen around the country.

Another example was where the Army R. & D. Command had been working on lightweight body armor. It's been rapidly introduced into use by local law enforcement officers, because the people in FLC and the Army decided that this was an important useful impact to society and they took a proactive point of view and tried to help that technology into the marketplace.

The last summary point here is to mention the Technology Innovation Center at the University of New Mexico, which I think is a very good example of bringing together the entrepreneur, the user, and as important as anything, trying to solve the venture capital problem all in one nice, neat package. I think it's one of the neatest, unique things that is beginning to happen in this area.

So in concluding, I want to say that the Federal labs in New Mexico have assumed leadership in the area of technology transfer and are very interested in pursuing an even broader role as the environment improves to be able to do that. And that's a summary of my paper, Senator.

Senator SCHMITT. Thank you. What are the greatest obstacles that you and your colleagues find when you try to develop a private sector interest in an area that you think they might be interested in? Is it not invented here or problem of patents or licensing?

Mr. WILLIAMS. I think part of it is attitude, an attitude on the part of both sides that we can solve the problem ourselves. Probably the biggest one is the question of proprietary information in the sense that if you wanted to talk with industry on a problem they have, you must protect their proprietary position. And mechanisms can be worked out, but they tend to be very cumbersome.

The other, I think, is the problem of the patent rights. If investment is to be made in R. & D. by the Federal Government, we tend to make that available to everyone. If exclusive patent rights were available so that a company who wanted to profit from exploiting that idea could have a position with exclusive rights, there's a much better chance that they're likely to take the risk. But the current environment and attitude is not to allow that sort of situation.

One good example of how this, I think, can be very effective is done at Harwell in England which is a similar national laboratory to the labs we have in this country, where they are the holders of the patents that are developed by the federally sponsored research. But they administer the program whereby the patents are exploit-

ed and they allow exclusive rights. In addition, the royalties flow into that laboratory and engenders in their operations an interest in finding more technical problems and more technical innovations that will solve the industry's problem. I think that's a system that could be very useful.

Senator SCHMITT. Do you see any negative aspects of a system like that in this country where Federal laboratories actually were allowed to market, in a sense, and to license the patents that were produced under their jurisdiction?

Mr. WILLIAMS. I think the key problem there, of course, is that—and it's not really a problem—if the private industry can do that on their own, they definitely should. But in general, when you're talking about large industry, they have the resources to do research and you certainly wouldn't want to compete with them in that regard, although if you can cooperate on a proprietary basis, I would think that would make sense. But it's the small business that doesn't have the resource to do the research that I think could benefit from this approach.

Senator SCHMITT. By the way—I have one or two more questions—we are attempting to notify the media that about 11:30 we'll have a break of about 10 minutes so that they'll have a chance to ask Secretary Baldrige or myself any questions they might want. Originally, that was scheduled for 12:45, but the Secretary was able to get here earlier. Now we'll try to move that up for the convenience, I believe, of everybody, provided we can get the word out that that's going to happen. So we'll shoot for 11:30.

Have you noticed any interest by other countries in your activities or activities that you might have some control over?

Mr. WILLIAMS. Of the laboratory?

Senator SCHMITT. Yes.

Mr. WILLIAMS. Yes, sir. We have had quite an interest, for example, by Japan and the Federal Republic of Germany in our geothermal program. I think you're familiar with that one. There's actually a cost sharing R. & D. program going on in that area.

Senator SCHMITT. Do they get into exclusive rights to the technology so developed?

Mr. WILLIAMS. Not at this point.

Senator SCHMITT. Why are they putting any money into it?

Mr. WILLIAMS. Because they are interested in assuring that it is developed. They may be a user before this country, and since the development began here, the idea started here, they want to make sure it comes to fruition.

Senator SCHMITT. Well, they must be taking something back. Are they taking lots of pictures like they used to do?

Mr. WILLIAMS. Yes, but they are also taking technical understanding of the drilling technology and the performance of the geothermal reservoir and that sort of thing. As you know, we're very free in telling countries, even when they don't participate, about our technology in this country. And in fact, one thing we ought to think about is how freely giving to all, all countries particularly, this technology might be to our disbenefit.

Senator SCHMITT. Can you imagine how in this country we would ever create any workable restrictions on that access?

Mr. WILLIAMS. No, it's very difficult. One of the important things about the strength of this country, I think, is that we are very communicative of these ideas. So people working in an area are pretty well, except for in classified areas, given access to what's going on.

Senator SCHMITT. Apparently that's going on even in classified areas.

Mr. WILLIAMS. Sometimes too often, yes, sir.

Senator SCHMITT. Do you feel that your learning curve and technology transfer has improved over the last few years, or do you think we are at a peak now and there are going to have to be some administrative or legislative obstacles removed before we can progress further?

Mr. WILLIAMS. Well, certainly we have learned and progressed over recent years as we have begun to be really involved in problems of the commercial sense, particularly in energy. But I do think the significant barriers are those that keep the risk relatively high for industry to exploit some of these technologies, and such things as the patenting and the licensing arrangements. I think we could benefit significantly by improving that situation.

Senator SCHMITT. How much is the problem just the right two or three people knowing each other and finding that there is something there that's useful? The principal stimulus for the Showcase for Technology was a general feeling that there was a communications barrier, that all of the great things that were here that were available for commercialization weren't known to anybody but the people that had been working with them in the laboratories and that we ought to provide a mechanism of seminars and exhibitions so that the potential users and commercializer of that could get to know the people who had made the inventions or who were working on the projects. Now, that was the stimulus behind the showcase effort, and from what I see, it's going to be a very successful operation. But is that generally the main problem you have?

Mr. WILLIAMS. I think that is a major problem, but I think, as in many complicated things of this sort, there are a number of links that have to be strengthened in the chain. I think things like the Technology Showcase are imperative in terms of the communications, because we have had an information explosion and there are a lot of ideas going on here, there, and elsewhere that need to be stimulated by this kind of communication.

But even then when two or three people get together and decide they have a great idea, it has to be in an atmosphere and environment that is conducive to their exploiting the idea, and that means they have to have access to venture capital, people who are willing to take the risk—and it's not clear what the risks are when you don't know what your patent position is likely to be or what the competition is likely to do in beating you in the marketplace.

Now, look at what happened when patent rights were allowed to people in the bioengineering area. All of a sudden that business is really booming and some of the best scientists in the country are going to work for private companies now, because they see a heck of an opportunity there.

Senator SCHMITT. Also, we don't pay them competitively; isn't that right, Mr. Secretary.

Secretary BALDRIGE. Have you heard any comments about the length of time it takes to get a patent having an effect on this whole process?

Mr. WILLIAMS. Yes, sir. My experience is with the Department of Energy, and for the Department to make a decision on whether or not they should patent a particular item or to allow special rights on the thing takes a long period of time because of the short staff that they have in DOE headquarters. These things can take many months, and there's quite a backlog. I don't think that's conducive to expeditious exploitation of the technology, especially when not all of them to take off, just a few can make a big difference.

Secretary BALDRIGE. I think the average time now is 26 months from the time a patent application is submitted until a patent is granted.

Senator SCHMITT. And the unfortunate thing, and one of the Commissioners will be out for the Showcase to help discuss this issue with the attendees, but one of the basic problems is when you look at the statistics, even if you get your patent you can count on at least 50 percent of the time of having to expend at least $500,000 defending an infringement suit or filing an infringement suit. So increasingly we're hearing in our testimony before the Science, Technology, and Space Subcommittee that companies are saying, to heck with patents, we'll just keep it secret; we'll get it on the market as fast as we can and try to make a buck and assume that somebody is going to steal it from us and we save the money having to defend it. And that's a terrible thing, because the founding fathers and everybody else recognizes the fundamental right to patent new ideas. It's in the Constitution and we ought to make it not only an easy process but one which is defensible.

Secretary BALDRIGE. Yes; far too many patents do not hold up in court. I think the figures you said were somewhere around half. We have got to improve that and we've also got to improve the pendency time of 26 months. What that magic number ought to be on that, I'm not sure yet, but it would be, I think, somewhere around 18 or 19 months, because that's about the minimum it takes to do the job right. But if the job is done right, that 50 percent of patents held valid should go way up.

Senator SCHMITT. Mr. Williams, one final question, and we may have a few for the record. In your written testimony, it says, "Exclusive licensing or waiver of patent rights to industry is not often possible." Why not?

Mr. WILLIAMS. It can have to do with the policy of an agency, such as the Department of Energy, who in general does not philosophically agree with that point of view. That's one reason.

Senator SCHMITT. I might add in that context, I think the testimony we've had is where NASA has granted a waiver of patent rights that on those they get about a 20-percent commercialization figure of the patent so waived, and I'm sure that's selective; but on others where they only grant exclusive license or have it available to exclusive license, the figure is down to 5 percent. So it's pretty important.

Mr. WILLIAMS. Yes. In cases where that has been done, there are some good examples of businesses that have prospered. I can think of two immediately where at Sandia, they were developing a clean

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air flow process using hepafilters, and at the time they didn't see a real benefit to the Government. I think a small company spun out of that. At Los Alamos, the technology for heat pipes was allowed to grow in that mode and has really benefitted the marketplace.

Senator SCHMITT. What are the usual terms of an agreement with industry on this issue?

Mr. WILLIAMS. I'm not familiar, in detail, Senator, with those terms.

[The statement follows:]

STATEMENT OF DR. EUGENE E. STARK, JR., INDUSTRY LIAISON OFFICER, LOS ALAMOS NATIONAL LABORATORY AND CHAIRMAN, FEDERAL LABORATORY CONSORTIUM FOR TECHNOLOGY TRANSFER

Mr. Chairman: It is an honor to submit this statement for the written record of these hearings.

DOMESTIC TECHNOLOGY TRANSFER

Technology transfer encompasses a variety of activities, including technical assistance, the practical application of Laboratories' unique expertise and technology, and information dissemination from the Federal Laboratories to the public and private sectors. It takes many forms, from the spinoff of space-age materials for consumer use, to providing expert advice to state and local governments, to cooperative efforts with industry to address national needs.

The passage of the Stevenson-Wydler Technology Innovation Act of 1980 is strengthening this process by making technology transfer a mission requirement of each Federal Laboratory. In recent hearings before the House Science, Research and Technology Subcommittee, representatives of several Federal agencies indicated active implementation efforts within their laboratories. We would expect to see, in the near future, a significant increase in technology transfer activities nationwide.

The motivation of the activity is twofold:

To impact our standard of living and the international competitiveness of American industry through enhanced productivity and commercial innovation by industry.

To enhance the efficiency and effectiveness of State and local government activities, particularly recognizing their significance to our standard of living and their growing responsibilities.

TECHNOLOGY TRANSFER IN NEW MEXICO

The Federal Laboratories in New Mexico have a history of technology transfer activities, and recent events have signaled renewed institutional commitments to technology transfer, using methods and emphasis appropriate to their situations.

These Laboratories are all active members of the Federal Laboratory Consortium for Technology Transfer, which is described later. Through this Consortium, the technology and expertise of New Mexico's Federal Laboratories are made available throughout the Nation; conversely, the expertise of other Labs are available to requestors in New Mexico through the Consortium.

Each Laboratory has a technology transfer contact with varying areas of activity. For example, there is a technology transfer program at the Sandia National Laboratories, which has in the past focused on response to inquiries and the transfer of new devices and methods to industry. Sandia's energy programs have appropriate cooperative activities with industry to strengthen the commercial potential of those programs.

Within the Institutional Relations Office at the Los Alamos National Laboratory, various aspects of technology transfer are assigned to an Industry Liaison Officer, a Government Relations Officer and a Community Relations Officer.

The Army's Physical Science Laboratory at the White Sands Missile Range has been active in outreach to local industry and in the Federal Laboratory Consortium.

The Air Force Weapons Lab transfers technology to industry primarily for defense-related applications through contracting.

Showcase for technology

This Conference represents a major commitment by these Laboratories, as well as by the three technical universities in New Mexico, to transfer their technology to American industry and more generally to establish appropriate institutional cooperation with industry. Over 100 scientists are contributing to this major event, which

is attracting nationwide interest. The attached "Summaries of Topic Committee Plans" indicates the wide range of technologies to be highlighted in the Showcase.

Later witnesses will describe just a few of the exciting technology areas that will be discussed in the Showcase. Because the primary emphasis of Showcase is on establishing the key person-to-person contacts between industry and the staffs of the universities and Laboratories in New Mexico, it marks an important new emphasis on cooperative relationships with industry that will benefit the participating institutions as well as the State.

Conference of mayors project

The US Conference of Mayors recently announced a pilot project, in cooperation with the Federal Laboratory Consortium, to link selected cities with local Federal Laboratories to establish a dialog and ultimately yield cooperation and transfer of technology and technical assistance to the cities. Albuquerque is one of these pilot cities and the Sandia National Laboratory has agreed to serve as the link.

THE PROCESS OF TECHNOLOGY TRANSFER

Mechanisms

The process of technology transfer can take many forms. Fundamentally, the first requirement is the recognition of an innovation, an opportunity, a need or a problem. This first step can be taken by either the Laboratory scientist or by a potential user of new technology in the public or private sectors. The next step is often a difficult one—making contact between the source and potential user of technology or technical advice or assistance. The brokerage often required to take this step can be provided by the Federal Laboratory Consortium, described below. In many situations, it is up to the Laboratory scientists to develop the potential for their new technology by publicizing it and making a deliberate effort to identify possible users and develop their interest in the technology.

The actual transfer of technology can then begin. Sometimes, it occurs quite easily and directly, based on mechanical drawings or even articles in professional or trade journals. Many transfers of this kind cannot be documented because they occur so directly.

At the other extreme, a new technology may be far from ready for commercial exploitation. A company may face a long and expensive development process and may need to obtain the detailed "know-how" emodied in the research and development work in the Laboratory.

Many of the more important transfers fall closer to the second example above. Although several different methods may be employed, the common thread is close person-to-person cooperation, so that the user may gain a detailed appreciation for the technology and any uncertainties in its applications, as well as the scientific and engineering "know-how".

This key person-to-person interaction occurs in several ways—in informal discussions, through visits and correspondence, in workshops or seminars designed specifically for technology transfer, and in special programs that allow industry staff to work in a Laboratory for an extended period of time.

In larger or longer-range programs, it may be desirable to initiate cooperative R & D ventures between industry and the Laboratories, taking advantage of each of their strengths and unique expertise. Ultimately, Laboratory involvement would decrease because the process of commercializing new technology is industry's responsibility.

In yet other cases, the unique expertise of a Laboratory may be applicable to a pressing problem in industry. Under certain circumstances it is possible for the industry to provide direct financial support to the Laboratory to address these problems. Consultation to industry may be provided informally in cases involving small amounts of staff time.

Another effective mechanism is the permanent movement of technical staff into industry, often through the establishment of new small enterprises. There are examples of such "spinoff" ventures from many Laboratories; these often remain geographically close to the Laboratory, thereby helping "home-grown" economic development. Several areas and technologies in the Showcase have the potential for this type of spinoff.

Subcontracting to industry can be a very effective mechanism. For example, a Laboratory may subcontract for engineered replicas of an instrument developed in the Laboratory, and the supplier may continue to manufacture the instrument for commercial sale.

The remarks of Dr. Dale Holm before this hearing provide important case examples of the variety and application of technology transfer methods.

Barriers

There are several important barriers to technology transfer. One is the technical capacity of the user to implement the new technology. This barrier is often addressed through close personal or institutional cooperation, when appropriate.

Another barrier involves the technical risk in moving a new technology into the marketplace. These risks are reduced as the Laboratory develops the technology, but at some point industry must assume the remaining risks.

The cost to adapt a Laboratory technology to commercial use can be high, and many companies expect some protection of their investment, e.g. by obtaining an exclusive license to a government patent. Exclusive licensing or waiver of patent rights to industry is not often possible.

The handling of a company's proprietary information can be a major barrier to cooperation; this problem is now addressed on a case-by-case basis, not always successfully.

THE FEDERAL LABORATORY CONSORTIUM (FLC)

Over 200 Federal Laboratories from 11 Agencies are members of the Consortium, which is sponsored by the National Science Foundation.

The goal of the FLC is to facilitate the effective use of Federal technology and expertise in addressing needs in the Nation's public and private sectors by providing the environment, the operational structure and the necessary transfer mechanisms. The fundamental value to New Mexico of the FLC is twofold:

By providing an efficient network of referrals among Federal Laboratories nationwide, the FLC contacts at New Mexico's Federal Labs can serve the needs of our public and private sectors even when the needed expertise is located far from New Mexico in another Laboratory; similarly, the FLC helps make the expertise of the Labs in New Mexico available nationwide, thus multiplying the effect of these Laboratories on the Nation.

The FLC has a major role in transfering the methods of technology transfer among the Laboratories. For example, the Showcase for Technology was conceived by Senator Schmitt based on an FLC sponsored technology transfer meeting in Baltimore.

One important function of the FLC is to work with users' groups, e.g. state leagues of cities, local-government innovation groups, and industry trade associations. This activity helps to multiply the technology transfer efforts of the Laboratories by efficient communications to potential users through their user groups. Another key value of working with these groups is that they assist in aggregating and defining the common needs or problem areas of their members. This aggregation further strengthens the payoff to the Nation of the Laboratories' technology transfer efforts. Two specific examples of FLC success stories are given below:

Light-weight body armor

Scores of law-enforcement officers' lives have been saved by light-weight body armor. These protective garments were developed by the Army Natick R & D Command and the Edgewood Arsenal for Department of Defense needs. Although the pressing need for better protection for policemen would have led eventually to the transfer of this technology, it was the encouragement of the FLC that convinced the Army Labs to push this technology into industry. The result is more lives saved, earlier entry into the marketplace, and approximately thirty companies manufacturing various garments based on this technology. The FLC has also provided assistance to numerous jurisdictions in preparing specifications for purchase of these garments.

Technology transfer conferences

As a Regional Demonstration Project of the FLC, the concept of a Technology and Business Opportunities Conference (TBOC) for industry was developed, with emphasis on how to do business with the government, and on the technology transfer and technical assistance programs of the Laboratories and the FLC. Two TBOC's have been held, one in Philadelphia in September 1979, and one in Baltimore on June 24, 1981. Both were very successful, due in large part to the cooperation of Federal Laboratories from several Agencies.

In March 1980, Senator Mathias and the FLC sponsored a technology transfer conference in Baltimore for State and local government officials.

The experience and success of these conferences has led to the Showcase for Technology to be held in Albuquerque on October 28-30, 1981, cosponsored by Senator Schmitt, the FLC, DOE-Albuquerque Operations Office, Sandia National Laboratories and the Los Alamos National Laboratory. The development and trans-

fer of this mechanism by the FLC will thus lead to a major opening of Federal technology to industry in the Showcase.

Response to the Stevenson-Wydler Act

The October 1980, Semi-Annual meeting of the FLC was dedicated to a comprehensive examination of Section 11 of the Act. Issues, concerns, barriers and action alternatives were developed in 2½ days of intense discussions. The Congressional intent was addressed by key Congressional staff. The major results of this meeting were a decision by the FLC to offer assistance to the Laboratories and Agencies in planning and executing their implementation of Section 11; and the formation of task forces to address the important issues: e.g., legal issues in technical assistance; preparation of the application assessments required in the Stevenson-Wydler Act; electronic conferencing and communications; state and local governments as users; industry as a user; personal-related issues in the technology transfer positions of Federal employees; and development of a list of Federal Laboratories.

In addition, as an information service to the Laboratories and Agencies, a videotape presentation on the background and intent of the Stevenson-Wydler Act was prepared, using interviews with Rep. George Brown, Rep. Wes Watkins and Sen. "Jack" Schmitt.

At the May 1981, FLC meeting, detailed discussions and directions for action were developed for cooperation of the FLC with industry. This was accomplished by inviting panelists from various sectors and sizes of technology-based industry to speak. Following their presentations, a series of structured workshops was held, with the industry panelists participating, to identify issues and to suggest action items. A report on the results of this meeting was issued recently; it provides directions for the FLC in strengthening its ties with industry.

NEW MEXICO'S ROLE

The State of New Mexico has taken an important step in establishing and supporting the Technical Innovation Center at The University of New Mexico. It will be discussed in more detail by another witness, but it should be noted here that this Center will assist the technology transfer efforts of the Laboratories by assisting potential entrepreneurs to establish companies based on technology developed in the Labs.

CONCLUSION

The Federal Laboratories in New Mexico have assumed a leadership role in many areas of technology transfer. This role will in the future be of increasing benefit to the citizens and institutions of New Mexico and further increase the State's contributions to the Nation.

ATTACHMENT

SHOWCASE FOR TECHNOLOGY SUMMARIES OF TOPIC COMMITTEE PLANS

Materials

Following an overview, there will be colloquia and exhibits emphasizing the following areas:

Metals and alloys.—Explosive metal-working, hardening, bonding and consolidation; super-hard alloys and related materials.

Ceramics/glasses.—Ceramic glass developments; ceramic sealing and joining research; colloidal ceramics and solid-gel technology; ceramic heat pipe technology; glass characterization laboratory.

Electronic materials.—Large-scale integration; photoelectrolysis; ferroelectric optics.

Polymers/plastics.—Plastic and polymer potting techniques, materials aspects, fabrication and applications; elastomers; polymer development and testing; high-temperature polymer applications.

Composite materials.—Fiber-reinforced composites; whisker composites; polymer composites; flyash-reinforced polymers; polymer concretes; fiber and packing technology.

Films/coatings.—Optical and solar coatings; superconducting thin films; TiB_2 valves; basic coating research, technology, applications.

New Mexico Joint Center for Materials Science.—Description of special educational programs, technical programs of the Joint Center.

Electronics

Three sets of presentations will cover electronics in severe environments, electronics education in New Mexico, and a panel presentation by electronics firms that have located recently in the State. The technical topics will include:

Radiation-hardened electronics.—For space and weapons, focussing on the Center for Radiation-Hardened Electronics at Sandia.

High-temperature electronics.—Integrated thermionics, high-temperature semiconductors and thick-film hybrid circuits.

Medical electronics.—Review of laboratory and university programs.

Geothermal energy

Overviews, topical presentations, a poster session and displays will emphasize:

Geothermal resource base in New Mexico.

Technology for geothermal development.—Drilling technology, logging instrumentation and interpretation; well stimulation; conversion systems and geochemistry.

Commercial development.—Hot dry rock; the Valle Grande geothermal area; direct use.

Solar energy

The following areas will be addressed in panel discussions and exhibits on laboratory, university, and industrial activity:

Solar energy for buildings—Active and passive heating and cooling.

Solar thermal power systems.—Central receiver; solar pond; experimental facilities.

Photovoltaics.—Residential test center; semiconductor devices laboratory.

Wind energy—Wind site survey; operational experience; vertical axis turbine.

Business climate for solar industry.—Solar Industry Development Corporation; incentives.

Fusion energy

Emphasis will be on the underlying technologies developed in the magnetic and inertial fusion programs, primarily on displays:

Ignition systems.—Explosive pulsed power; imploding foil experiment; pulsed power; CO_2 lasers; light ion beams.

Inertial fusion.—Target fabrication and plasma diagnostics.

Magnetic fusion.—Materials; alternate concepts; tritium handling technology; data acquisition and controls; plasma physics and diagnostics.

Fission energy

Posters, displays, and videotapes will be employed.

Commercial fission fuel cycle.—R&D activities related to prospecting; mining, milling, and environmental issues; laser enrichment; fuel fabrications; reactor safety; spent fuel storage; laser reprocessing; disposal.

Radioisotopes and radiation applications.—Space nuclear reactors; medical applications; neutron radiography; education and training.

In-situ technology and fossil energy

Following a comprehensive overview, a panel discussion and posters will cover these areas:

Resources.—Assessment and site characterization.

Resource access.—Drilling technology, mining.

Permeability enhancement and reservoir preparation.—Explosive rubbling; fracturing; chemical and thermal treatment.

Innovative instrumentation

Resource recovery processes.—Solution mining; underground coal gasification; in-situ oil shale retorting; in-situ tar sands and heavy oil recovery; enhanced oil recovery; natural gas from unconventional formations.

Environment

Presentations, posters, and displays are planned to cover:

Water.—Reuse, treatment.

Instrumentation.—Radiation detectors and other devices that are about to be, or have been transferred into the private sector; LIDAR.

Beneficial uses.—of waste products.

Complex terrain modeling.—of air flow.

Particulate control technology.—A new technology for removal of small particulates.

Scale prevention in pipes

Industrial hygiene

Agriculture

Technologies to be presented in displays include: Radiotelemetry of deep-body temperature in mammals; electrothermal treatment of cancer eye in cattle; electronic identification of livestock; genetic manipulation of plant material for saline water and drought tolerance; applications of computer technology; solar and geothermal applications; immunoserological techniques for disease and toxic agent detection; aerial application technology and pesticides; hot carcass processing of beef; radiation renewal of sewage.

Photochemistry

An overview and technical presentations will be complemented by displays, posters, and films:

Laser isotope separation
Photochemical purification of materials
Optical diagnostics
Combustion studies
Photochemical forming of metals and plastics
Atmospheric photochemistry
Laser annealing

Life sciences

Four major areas will be emphasized in presentations:

Insulin pump
Flowing cell analysis
Computer-assisted morphometric analysis
Pion radiotherapy

Lasers and modern optics

The presentations will be on three major topics—overviews of the major laser and optics R&D programs in New Mexico; a session on the most exciting new technical areas; and the experience of laser-related industry in New Mexico. There will be exhibits and posters as well. The technical areas emphasized are:

Lasers.—Chemical; pulsed D–F; tunable infrared and ultraviolet; free electron; ring lasers; lasers for fusion.

Optics.—Laser gyros; adaptive optics; applied laser spectroscopy.

Technology.—Electron beams for laser excitation; electro-optics; large optical elements and systems.

Explosives technology

A comprehensive overview will be presented twice. Overviews of the topic areas will be the subjects of presentations, posters, movies, and a demonstration:

Advanced high-explosive developments.—Synthesis of high explosives; thermally stable energetic and insensitive explosives; ammonium-nitrate-based explosives; detonation phenomenology.

Applications of shock and blast waves.—Alteration of material properties by shock loading; simulation; high-temperature environments; detonation wave shaping; metal fabrication with high explosives; explosive-operated valves, switches, fasteners; explosively driven electric power supplies and magnetic flux compression; explosive logic circuits; exploding bridgewire detonations.

Operation safety.—Safety analysis; thermal-hazard and lifetime predictions; environmental effects; accidental mechanical detonation.

Computer modeling and networking

A walkthru exhibit area will provide an overview of computing in New Mexico, technology transfer opportunities, education, and the future applications, e.g., parallel processing, intelligent terminals, automated offices.

Computer-aided design, manufacture

On-site displays and demonstrations and discussions will focus on:

Computer-aided design.—of mechanical products and electrical circuits.
Computer-aided design analysis.—of mechanical and structural properties.
Solid modeling.—Constructive solid geometry.
Communicating the engineer's design intent
Manufacturing.—Preparing instructions for numerically controlled machines.

Atmospheric sciences

The development of this area is just beginning; however, it has been decided to emphasize exhibits located near the Space Technology and Remote Sensing exhibits.

Space technology and remote sensing

New technologies and practical applications of space technology will be displayed in exhibits:

Geological characterization; crop surveillance; fault zone mapping; new heat source; reactors for space power; solar and stellar astronomy; satellite-borne telescopes; fiber and laser optics; satellite-borne lightning sensors; image processing; cultural resource studies; volcanic plume tracing; surface material classification; saline seepage; environmental improvement.

Business opportunities

Using brief presentations and a booth, procurement officers from the major federal institutions will discuss subcontracting and procurement opportunities.

Moving technology into the marketplace

The specific presentation on the movement of technology from the federal laboratories into industry will be placed in the keynote session—the opening plenary session of the Conference. Based on considerable advance discussion with agencies and laboratories and reviews of case histories, this presentation will outline the ingredients for successful Laboratory-industry cooperation, the available mechanisms and the barriers to cooperation and what is being done to alleviate them. The Laboratories' plans to continue and strengthen the contacts begun in the Showcase will be outlined.

Senator SCHMITT. Thank you, sir. We appreciate your testimony. We could continue with this discussion for a long time, but we must, instead, move on to our panel. Thank you, Jim.

The first panel is Dr. Leonard Napolitano, dean, University of New Mexico School of Medicine, and Dr. Edward Barsis, department manager, Electronic Subsystems Department, Sandia National Laboratory.

Mr. Secretary, I think you're going to find this discussion a very interesting one. It's a technology transfer that is in work, but everybody is pretty enthusiastic about it.

Dean, are you going to lead off the discussion?

Dr. NAPOLITANO. The admonition to keep the remarks to 5 or 10 minutes we'll try to follow closely.

Senator SCHMITT. I might say, Mr. Secretary, while he's orienting his thoughts, we're very, very proud of the University of New Mexico's research activities, as well as their treatment activities, here in the area of medicine. And they are developing an increasingly strong relationship with the national laboratories, both Los Alamos and Sandia, in applying new technology to a variety of medical treatments, particularly in the cancer area, but you're going to hear about another issue today.

Go ahead.

STATEMENTS OF DR. LEONARD NAPOLITANO, DEAN, UNIVERSITY OF NEW MEXICO SCHOOL OF MEDICINE: AND DR. EDWIN BARSIS, DEPARTMENT MANAGER, ELECTRONIC SUBSYSTEMS DEPARTMENT, SANDIA NATIONAL LABORATORY

Dr. NAPOLITANO. There is on area of activity in the country and in the world that is really not contested and that is that the United States unquestionably at this time is No. 1 in biomedical research. The reason for the United States occupying this role is the investment that the Federal Government has made following the Second World War through the National Institutes of Health, which have directed themselves for some 35 years into basic research to information as it applies to the various disease entities that afflict not only people in the United States but worldwide.

At the present time, the health industry occupies about 9½ percent of the gross national product, an extraordinarily large amount of dollars. As one projects health care costs into the nineties and into the year 2000, other than containing health care costs new mechanisms of treatment, new modalities of treatment to the common diseases need to be developed so that more effective treatment, more-cost effective treatment and a higher quality of life for citizens can be realized.

About 5 years ago faculty from the School of Medicine and scientists at Sandia National Laboratory began collaboration relative to looking at a problem that has existed since the early 1920's—that is the treatment of diabetes by insulin, a disease that is extraordinarily common in our society and throughout the world.

The treatment of diabetes—it's a complex disease that has a fundamental problem in carbohydrate metabolism—has fundamentally been the same since the early 1920's when Banting and Best utilized the pancreas of dogs to treat human diabetes, and that's the injection of insulin intramuscularly or subcutaneously into individuals. Approximately a millon and a half individuals in the United States take insulin shots as a daily routine.

The scientists at Sandia thought this was relatively a prehistoric method of introducing a drug on a daily basis, and collaborative endeavors have been taken since that time in developing an instrument which can deliver insulin in a known amount, a controlled amount, in a different way than by injecting it with a needle into subcutaneous tissues.

As you may or may not know, you don't need a prescription for insulin. What the doctor writes a prescription for are the hypodermic syringes that the person gives himself insulin with. You don't write a prescription for insulin, it's for the syringe. That probably has effects on other aspects of drug culture and so forth, but we won't get into that at this time.

The net result of this 5-year cooperative endeavor was that in January 1981, following a series of closely controlled experiments in dogs, the first human implant was accomplished. The individual continues to be closely monitored at the clinical research facility at the university hospital. This is a unique facility in which patients have access to analytical tools on a 24-hour-a-day, 7-day-a-week regimen and can be followed with an accurate assessment of the instrument.

In a broader sense, the development of the insulin pump, which Dr. Barsis will address very shortly, is a mechanism or a tool to introduce an external vehicle, in this case insulin, into the body. But its application or potential application to a variety of other hormones, chemotherapeutic agents, and so forth, has yet to be realized. With this instrument one is looking at, from commercial venture, a growth industry which will be occurring over the 1980's.

With that as a kind of general introduction to the development of the insulin pump, speaking on behalf of the clinical faculty at the school of medicine who have participated in this, Dr. Phillip Eaton and Dr. David Shade in the department of medicine, as well as a large number of fellows, medical students, who have played roles during the course of this investigations, I'll turn this over to Dr. Barsis, who in turn will describe precisely the collaborative

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effort between the National Laboratory and faculty at the school of medicine.

Dr. BARSIS. As Len mentioned, the purpose of this insulin pump was to simulate a normal pancreas. It's believed that the debilitative side effects of diabetes, such as loss of limbs, loss of kidneys, blindness, heart failure, is due to the nonsimulation of a normal pancreas by subcutaneous injection. In fact, the side effects of diabetes is now the third leading cause of death in the United States.

The insulin pump that was developed in collaboration with the University of New Mexico consists of a reservoir which is implanted just under the skin and a pumping mechanism contained here [indicating] which pumps insulin from the reservoir into the peritoneal cavity.

The part of this that you can see contains a small battery power supply source, integrated electronics, which represent several thousand transitors and which are similar to the electronics we put in weapons systems, and also this small, miniature pump, which is very similar to safety devices that go in nuclear weapons.

The device delivers a background rate of insulin—and it can deliver 15 different background rates, depending on a patient's needs—and also a mealtime dose, which is determined by the patient's blood glucose level and the calorie content of the meal. This is a controller which controls the background rates and the mealtime delivery. A patient would hold it here, key in what he wants to do, and transmit the information to the insulin device. It's a two-way communication link and the implanted unit can talk back to the controller and give the status of what it's doing.

I might just demonstrate that. First, I'll ask for a status check to see what the insulin pump is doing, and I'll transmit to it. The buzzer meant the transmission was complete. It took a little while because before the implant transmits back, it does a lot of self-internal checking to make sure the transmission was correct and the patient hasn't asked it to do anything which would be unreasonable, that is, not programed. Next I will see what this insulin delivery system is programed to do; and currently it's programed to deliver 1 unit of insulin per hour and it's delivered a total of 206 units of insulin since it was started, and at mealtimes it will give a mealtime dose of 13.3 units of insulin.

Now if I was a diabetic eating a meal, I could start the mealtime dose, and I'll do that. The buzzer meant that the mealtime dose was a legitimate dose. You should hear the pump ticking in a little while, about every 8 seconds or so. I don't know if you've heard it, but it is now giving a mealtime dose.

The difference between this and other units being developed is that this is a fully programable unit with two-way communications which can give different base rates and different mealtime doses as well as status.

We started working on this because we thought it was something that needed doing very badly and that we were uniquely suited to do it. We used about half external funds from the National Institutes of Health and the Crock Foundation and about half internal funds.

We've now reached a milestone where we have shown success and it is not appropriate to use internal funds or military money to do some of the things that need to be done now. In terms of a multiprogram, national laboratory, we've reached an important milestone. For example, the physicians at UNM would like 30 to 40 units to do a large-scale clinical study. It is not appropriate to use military money to have these manufactured for clinical studies; perhaps one of the health agencies or someone interested or responsible for commercialization should pay for that, and I see that as one barrier to commercializing this device.

I'm going to turn this off.

Another barrier is the requirement for continued development. Next year we're starting on the development of a new advanced system which would be clinically acceptable for widespread use. It would be lighter, smaller, increase the battery life from about 2½ or 3 years to 5, and also include some safety features which would be necessary for widespread clinical use.

We have a grant that's been approved from the National Institutes of Health to do this; however, what we expect from the National Institutes of Health isn't enough to do the complete job. And there again, it's questionable whether military money should be used now to make this unit clinically acceptable since the concept has already been shown feasible. Lack of funds for this development could be a potential barrier.

We've started talking to commercial companies, and in October we are inviting in about 100 different commercial vendors in conjunction with the Showcase for Technology. We're going to present our work and find out who would be interested in picking up the manufacture of this device.

However, from preliminary discussion with some of these vendors, we're getting the feeling that they're going to be reluctant to put in their own money now, in view of the fact that in 1½ or 2 years there will be a better device available and they could, under the present way we operate, have no guarantee that they would have exclusive rights to that new system. So that may be, also, a barrier, in addition to the fact that a large number of units, a relatively large number, are needed for clinical studies by the medical people.

Any questions?

Senator SCHMITT. Thank you.

Mr. Secretary, I'd just mention that this is one of many examples that are appearing now where our increased understanding of the natural biotechnology of the body is enabling us to substitute devices such as this where those natural technological functions fail or are inadequate and to also look toward even more specific preventive measures by understanding early that those natural mechanisms are not there or are going to fail or are failing.

We didn't mention it, but I presume that you add to that something else that is happening elsewhere, and that is that with the production of human insulin, we begin to not only have a more bodylike artificial pancreas, but we can use human insulin rather than animal insulin and avoid some of the current side effects of the current regime of treatment. So although this is just one example, it's an exciting one. But you can see already from the testimo-

ny some of the problems that exist in getting this into wide scale use.

Are there any regulatory problems, FDA certification, things like that that one has to think about in the future?

Dr. NAPOLITANO. At the present time, the clinical faculty and the clinical research center are cleared from the clinical faculty and the clinical research center are cleared from the FDA as an early experimental device, and the next step would be, as that broadens, to continue to interact with the FDA. Ultimately before this became a commercial venture there would be additional types of studies to demonstrate the efficacy, safety, and so forth, in which there would be even more intimate, I would think interaction with the FDA. At present time, that's not a problem. It's still in a clinical experimental state.

Senator SCHMITT. Can you foresee that at some point, if everything progressed as you hope it will, it will hit obstacles that will be difficult to overcome?

Dr. NAPOLITANO. I'm sure we'll hit obstacles

Senator SCHMITT. Are they ones that shouldn't be there, that are unnecessary obstacles?

Dr. NAPOLITANO. No, I think in many respects the FDA has a mission and responsibility for safety in terms of a broad approach to the treatment of specific disease entities, whether it be a pump kind of mechanism as opposed to a new compound and so forth.

Senator SCHMITT. Is there a patent on this?

Dr. BARSIS. No, there isn't.

Senator SCHMITT. Is there a patent on any part of it?

Dr. BARSIS. No. It's a combination of high technology—a patent hasn't been applied for and it's questionable if a patent were granted, whether it would be significant in terms of changing enough things to break it anyway. But there is no patent on it now.

Senator SCHMITT. Then what is the reluctance of industry, say, to just pick up the drawings for those parts and start to commercialize and develop whatever patentable items they can themselves?

Dr. BARSIS. In October we'll have a better feel for it, but according to the people we've talked to so far, it's basically that in 3 to 5 years we're going to have a unit that's half size, that lasts 5 years, and that has additional safety features built in; and anyone that picks up that model will be way ahead of anyone who spends $2 million to build this one.

Senator SCHMITT. So they, rather than build that half size model, they'll wait and let you do it and pick it up later; is that the idea?

Dr. BARSIS. That's possible.

Senator SCHMITT. They don't want to compete with you and see if they can give the dean in 1 year something that is——

Dr. BARSIS. I think if they were willing to do that it would be time for us as a national laboratory to get out of the business and let them pick it up. If that were the case, we would happily get out.

Senator SCHMITT. Now, besides treatment of diabetics, how large is the market, potential market?

Dr. BARSIS. A firm on Wall Street estimated the market as several million units, potentially, by 1990 for diabetics. For cancer and other forms of drug delivery treatment. I don't know. I can believe 1 million diabetics.

Senator SCHMITT. A million out of, what did you say, 1½ million, this would be a legitimate, reasonable, clinical treatment?

Dr. BARSIS. Well, it turns out to be shown clinically that, in fact, the accurate control of blood glucose does eliminate the side effects—blindness, loss of kidneys, heart failure—then I'm sure that most diabetics would want one.

Dr. NAPOLITANO. You're just talking about the market in the United States. Diabetes is not restricted to the United States.

Senator SCHMITT. Oh, that's right.

Dr. BARSIS. I think if the third leading cause of death were eliminated, a lot of people would want it.

Dr. NAPOLITANO. The problem with diabetes is that as a biological problem it has been studied extensively for the last 50 years with the most contemporary techniques. There are still some basic questions that one doesn't have answers to, and that is, with the control of a diabetic by insulin one brings down blood glucose levels to "management levels" where the person gets along reasonably well.

As compared to not having insulin, we're really in great shape, but the diabetic still is in an abnormal state. Blood glucose is at a significantly higher level than normal, although the patient is "well maintained". It is felt that the tertiary effects of diabetes may be due to the elevated blood glucose levels, even though the patient is well maintained in a diabetic controlled state.

One does not know at this time, and it's going to take a long study to determine whether the effects on peripheral vasculature, on the heart, on the eye because diabetes is the leading cause of blindness, whether those are really effects of the hyper but controlled glucose levels or not. And it will take a significant investment over a long time in a well-controlled, both laboratory and clinical study, to make that determination.

This is an instrument at the present time where one can undertake those studies and know that the data that is going to be forthcoming is going to be the kind of data that is going to be capable of interpretation and giving one an answer. Unfortunately, everyone wants answers here and now.

Senator SCHMITT. So you're saying it's a tool for not only treatment but research.

Dr. NAPOLITANO. Absolutely.

Senator SCHMITT. How is the young man I met?

Dr. BARSIS. He's doing fine. In fact, his glucose levels have been in a normal range for several months. The unit seems to be simulating a normal pancreas very well.

Senator SCHMITT. And that's part of the uncertainty is that maybe the way we've treated, the way past treatment has been, may have contributed to the tertiary effects.

Dr. NAPOLITANO. The person takes one shot of insulin a day. That isn't the way the pancreas works. It probably would be better if a person would take three shots, one with each meal, but people are not interested in taking three shots. They really don't like to take one.

Senator SCHMITT. What about the possibility that the differences between human and other animal insulin contribute to these side effects?

Dr. NAPOLITANO. That's been explored in some detail, but I don't think there are any answers in that regard. The current studies indicate that human insulin, both as a technique of molecular biology and the new biology being produced out of bacteria, there have not been, at least that I'm aware of, significant differences between that type of insulin versus insulin from pork, which apparently has fewer side effects than insulin from beef. But as one projects, not only in the United States but in the world, the need for insulin from animal sources, be it pork, beef, or other, one reaches a crossover point in the mid-1980's where there may not be enough insulin from those sources to supply all the diabetics in the world.

The problem with diabetes in China, for example, is an interesting problem. It may well have been controlled by their caloric intake, but as their caloric intake goes up, they may have much more difficult problems in their treatment of diabetics.

Senator SCHMITT. Dean, what do you see in the trends in the investment in biomedical research right now? Do you see an improving climate?

Dr. NAPOLITANO. Yes. The interesting trend that's remarkably different from a commercial point of view—I'm not an expert in this field—but is that people are putting up front capital in ideas. We take genotech or genetic engineering or a variety of companies where they don't have a product, and what they have fundamentally is an idea and the anticipation of the capability of making a product with a large amount of venture capital coming in, that's a relatively new experience where people are putting significant amounts of money into ideas in anticipation of a product.

On the other hand, we have a product and potentially are looking for some venture capital. More particularly what we're looking for, what is needed, is more of this product on the basis that there is going to be research and development that makes this product obsolete in 2 to 3 years, and that's the difficult part in terms of the commercialization.

Senator SCHMITT. What is that investment for the clinical tests that you're talking about using that product?

Dr. BARSIS. Probably about $300,000 to $500,000, something in that range.

Senator SCHMITT. And you think that would, then, permit a definitive clinical test and that could be the basis, then, for broad scale introduction of this technology into the medical profession?

Dr. NAPOLITANO. It depends on how you define "definitive," Senator. It would certainly give us much more information than a series of dogs and one or two patients that we have at the present time. All of the data so far in terms, as I read the reports from our clinical faculty, is that it exceeds expectations on what they are able to observe relative to controlling carbohydrate metabolism in the experimental animals.

Some unique experimental animals are now in possession of pumps: A particular strain of dogs from Michigan State that has a genetic defect producing diabetes may give different information than dogs that are treated chemically to knock out beta cells in the pancreas.

Human beings, being as varied as they are and as their response to particular kinds of internal things as varied as they are, one needs a larger group in order to consolidate and confirm the observations that are currently being made.

Secretary BALDRIGE. Have you heard much in the way of discussion about the proposed lengthing of the patent life of drugs and pharmaceuticals as being a spur to increased commercialization?

Dr. NAPOLITANO. I really can't answer that.

Senator SCHMITT. You know what he's referring to, that the 17 years started to be measured from the issuance of the patent rather than from the application?

Dr. NAPOLITANO. Yes, I am. I can't address that.

Secretary BALDRIGE. I would think that would be significant.

Senator SCHMITT. It seems to be. We've had some supportive testimony on that, and I would think that would be a fairly simple thing to do, and we ought to do it first chance we have.

Dr. NAPOLITANO. The only other point I would make, Senator, is that the school of medicine feels itself, both with unique opportunities in terms of interacting with the national laboratories and the State that have technologies that are not easily duplicated anyplace else in the world and the ability for scientists from the national laboratories and our own faculty to interact and, at times, address problems that are serious problems in terms of health care needs of society, offers unique opportunities for our faculty and, I think, the national laboratories.

And the real question is how best we can increase these interactions. There are significant interactions gong on at Los Alamos; the insulin pump perhaps is the most dramatic interaction going on at Sandia. But I know of other interactions that are going on at Sandia, but not as dramatic and not at this stage of development.

Senator SCHMITT. Now, we have a final question. Examples of where around certain research environments major commercial complexes develop, Route 128, Silicon Valley, and just a cursory look at this it would appear that that happened because the researchers themselves could leave the research environment with a patent or with an edge on the rest of the industry through their research and attract venture capital and start a small company that grew into massive proportions, in some cases. That has not yet really happened in this area. There are a few examples.

Doctor, if you were so inclined, what are the barriers to you and maybe your colleagues just stepping across Central Avenue or Wyoming or someplace up there and setting up a small operation to manufacture these and to advance the technology?

Dr. BARSIS. Well, one——

Senator SCHMITT. I'm not claiming—this should not assume that you would be so inclined, but what are the barriers to somebody else potentially doing it?

Dr. BARSIS. Well, one consideration is that this is a combination of fairly different high technologies. It's a very elaborate mechanical gadget, and we've had some of our best engineers working on that. The electronics are also very elaborate. In fact, in this package there are 8 or 10 of the items that somebody might set up a private company to do in Silicon Valley—just in this little package.

This is a titanium can and it's sealed for implantation using laser welding, which is still not an easy thing to do.

So I would think that one of the obstacles to a small company getting started in this is the multitude of high technologies—you'd have to be a lot more than a garage shop operation and would need a lot of capital.

Senator SCHMITT. Does that mean we might consider allowing Sandia to set up a small affiliate that could initially, at least, utilize the resources of the lab to manufacture early units while they develop capital resources to go into full-scale manufacture?

Dr. BARSIS. It would probably be more efficient to provide the money so we could go out on contract to one of the many commercial vendors, people who currently make pacemakers, for example. We could contract with them and control the quality of what they make. This is the normal way we do weapon components. We do design and prototypes, then we go out on contract to actually have the weapon component made. This is the way we normally operate, and would probably be the most efficient use of funds.

Senator SCHMITT. But you would maintain you would be the integrator and marketer?

Dr. BARSIS. No; the company that made it would be the marketer. We would, having done the design and the development, monitor the initial production units to make sure they met good standards of reliability and so on, then get out of it.

Senator SCHMITT. With no return, royalties?

Dr. BARSIS. Right, no return, no royalties.

Senator SCHMITT. Have you seen any one of these types of companies interested?

Dr. BARSIS. There are a lot of them interested if we're going to put money into setting them up. But as I mentioned before, to set someone up to make these for clinical studies is not really an appropriate use of military or internal money.

Dr. NAPOLITANO. Maybe we ought to talk about that, Senator.

Senator SCHMITT. Well, it certainly sounds like we have a barrier here that is going to be a little bit difficult to overcome, unless somebody just finds $500,000—well, that's your cost for making the unit. It would be far more than that to set somebody up.

Dr. BARSIS. No, I was talking about—because we have been thinking about the seminar in October—an estimate of what it would cost a commercial outfit to do it.

Senator SCHMITT. And you're expecting about 100 individual companies to participate in October?

Dr. BARSIS. We invited 100; we expect about 50 to attend.

Senator SCHMITT. OK. Well, thank you, gentlemen. We appreciate that. It's a good case study. It seems to be progressing, but there's no clear, final outcome. It does have its own barriers. It probably illustrates the case, specific nature of so many of these technologies.

Secretary BALDRIGE. It does, and the volume, I think. I think the private industries would be looking at that million and a half, how much they could reasonably expect to get and how long it would take to get there after all the clinical studies are done before they could figure out how much was at risk.

Senator SCHMITT. Have you made an estimate of the per unit commercial cost if you overcame these barriers and were manufacturing them at a reasonable pace?

Dr. BARSIS. No; we decided not to do that. One of the reasons we decided not to do that is because we are having a lot of companies in very soon and we'll let them take a crack at that.

Senator SCHMITT. Good idea.

OK, let's take a recess for about 10 minutes. In that period of time, if the media would set up quickly, we'll let you impose yourself on the Secretary of Commerce.

[Recess.]

Senator SCHMITT. The hearing will come to order, and we'll proceed with our next panel: Dr. Anthony Veneruso, Supervisor, Geo Energy Instrumentation, Sandia National Laboratory; Dr. Margaret Cox, Detonation Research Scientist, Los Alamos National Laboratory; and Dr. Dale Holm, Staff Member, Los Alamos National Laboratory.

Dr. Veneruso, I believe things will flow best if you give us the testimony, summarize as you can, and then we'll have time for some questions.

STATEMENTS OF DR. ANTHONY VENERUSO, SUPERVISOR, GEO ENERGY INSTRUMENTATION, SANDIA NATIONAL LABORATORY; DR. MARGARET COX, DETONATION RESEARCH SCIENTIST; AND DR. DALE HOLM, STAFF MEMBER, LOS ALAMOS NATIONAL LABORATORY

Dr. VENERUSO. First of all, I want to thank the Senator and the committee for this opportunity to talk about a project at Sandia that we're in the process of completing, and it has to do with downhole instrumentation for geothermal energy. Now, as in the case of the oil and gas industry, we really need information from the downhole environment to quantify the productive potential of the particular reservoir. In this case we are interested in a geothermal well, where we want to measure temperatures, flow rates, pressures, all those things that have to do with the productive potential of the geothermal well.

However, the kinds of instruments that are available in private industry now operate only up to 150° C; these are satisfactory for oil an gas exploration but not for the geothermal wells where temperatures range up to 275° C. Industries and producers who are interested in geothermal energy research are not inclined to risk investment and capital without information as to what's down there in the formations and what the productive potential of those wells are so that they can get the necessary capital and build a powerplant and so forth.

We started this program under what is now the Division of Geothermal Energy in the Department of Energy. We started in 1975. I would like to make two points about our work: First, that the technology transfer was an integral part of our work; and second, that the technology transfer is our end product, it's our most important product.

Another point I want to emphasize is that this energy R. & D. program is a way of transferring the knowledge and expertise in technology that we have concentrated at the national laboratories

and to get that out in order to stimulate production, inventions, and developments by private industry.

I'm happy to report that we're concluding this program. We have achieved our goal of 275° C. operation. We have stimulated some new businesses, both large and small, in the area of high temperature electronics. This high temperature electronics is being applied not only to geothermal energy—as we were paid to do by the Federal Government—but also to many other areas that we found along the way. Fortunately we had an industry-based advisory panel that we had set up from the very beginning to advise us on the best way to do this technology transfer.

Now, we're seeing applications of this high temperature electronics in such diverse areas as future space exploration, since the surface temperature of Venus is very high. We're seeing it in jet engines that the Navy needs for control instrumentation and increased reliability of jet engines. We're also seeing it in the industries we first approached with this geothermal project in that they're applying the technology for enhanced oil recovery via steam injection, where you intentionally make the formations hot, then you need instrumentation to measure the production parameters.

I have some samples here of the work we did. Along the way, we focused our attention on providing the fundamentals of the technology and complementing the industries that we were working with by focusing our technology developments on those things that we knew were generic and that would stimulate industry's own invention.

For example, I have here the high temperature circuits. We developed the first ones, adapted them to high temperature at Sandia, did a further refinement under contract to a company that develops circuits for a living, and then they, with their own investment, turned that into a high temperature circuit that is now being marketed not only in the United States but in Japan and Europe as well.

I also have a sample of what happens to a conventional circuit at high temperature. As you might expect, it doesn't come out looking very good.

We did try to steer ourselves, as I said, in the direction of the basics, but along the way we did come up with a couple of inventions. One of these was a quartz crystal double-ended tuning fork. And again, I'm happy to report that a new business has started and has been granted a patent waiver by DOE to produce the item. They are producing the item and it's a going concern.

We have many instances of international cooperation where we learned an awful lot from the Japanese—that came out today—but they also made an extraordinary effort to keep up with what we were doing; the result was we learned a lot from them and they are now buying some of the products that industry in this country is producing.

That's all I have.

Senator SCHMITT. Thank you, Doctor. I take it that's your probe?

Dr. VENERUSO. Yes, this is a geothermal probe, a temperature probe. It was used here in New Mexico and also in California to measure temperatures to 274° C.

Senator SCHMITT. Do you see there is any practical limit to the downhole temperature you might be able to measure? Presumably the melting point.

Dr. VENERUSO. This is always a challenge, to push the technology further and further. Our first barrier was the silicon transistors themselves, and it appears that their limit is about 300° C. If we go to other things like ceramic tubes or even solid state components, what's called the company semiconductors, these could go up to 450° C. to 500° C. After this you must consider the things you mentioned: The melting points of some of the metals; also, the polymers involved begin to degrade to the point where they're useless above 300° C.

We now have a better idea where these limits are, and this information is beginning to feedback into the weapons programs, as well as other programs where we need to know what happens to materials, in hostile conditions such as fire, explosion, and so forth.

Senator SCHMITT. Are you looking at optical means where you could go to very high temperatures and sense the changing optical characteristics through optical fiber transmission, things like that? Is that part of the effort also?

Dr. VENERUSO. Yes, we did look at that and had initiated some feasibility work where some cable fiber, optical cable, was tested. And it was a temperature probe using a germanium crystal, and the temperature would affect the crystal's ability to transmit light.

Senator SCHMITT. Was that what you look at for very high temperature sensing?

Dr. VENERUSO. Yes, that is what you could call exploratory development. We did encounter some difficulties, not with the fiber itself but with what's called the buffer or the insulator around the fiber. It was made out of a plastic material which degraded at 300° C. This research led to other things such as a ceramic cable. A company that we had subcontracted some of the early investigations to, Halpen Engineering of Buffalo, N.Y., is now in the process of proving to themselves that they have a commercial product and they've been exhibiting their successes at the various trade shows around the country. This started with some of the seed money from our program.

Senator SCHMITT. Did that require a waiver or license from you, or was that something they could do themselves?

Dr. VENERUSO. Basically, we saw they had started and had established some of the early technology of wrapping a ceramic material with a stainless steel sheath. In a sense what we did was pay for the further testing and some of the development of an idea that was already established.

[The statement follows:]

STATEMENT OF DR. ANTHONY F. VENERUSO, SUPERVISOR, GEO ENERGY INSTRUMENTATION, SANDIA NATIONAL LABORATORIES

On behalf of Sandia National Laboratories, I thank Senator Schmitt and the Senate Subcommittee on Science, Technology and Space for this opportunity to give information concerning a successful program we are now completing in the area of high temperature electronics for geothermal energy applications. In this presentation I wish to illustrate two major points: first, that technology transfer was an integral part of our program from its inception; and second, that technology transfer is the end product of our energy R & D programs.

High temperature borehole instruments, or logging tools, are essential to provide information so that the private sector can explore, develop, and produce geothermal energy resources. These instruments also provide information concerning the production potential and longevity of a particular geothermal field; this reduces risk, helps stimulate private investment, and thereby promotes the rapid production of geothermal energy resources.

The need for high temperature electronics work stemmed from the fact that there were insufficient incentives in 1975 for industy to carry out the high risk R & D required to correct some serious technical deficiencies in the state-of-the-art. The basis problem was that the available logging tools were designed for oil and gas applications up to 150°C and they would not operate in geothermal wells where temperatures range from 150 to 275° C. The key technical deficiencies were not so much in the design of the logging tools themselves, but rather, in the lack of suitable high temperature electronic materials, components, and circuit fabrication technology. Logging service company representatives stated that once they had this generic high temperature technology they could develop and apply the tools required by the growing geothermal industry. We therefore focused our efforts on developing the fundamentals of high temperature electronics technology and evaluating prototype geothermal instrumentation in joint development and test projects with private industry.

In 1975, Sandia was asked by what is now the Department of Energy's Division of Geothermal Energy to start our work. Sandia was chosen for this task because of the concentration of our scientific and engineering expertise in electronics, instrumentation and system design for hostile environments.

The first action was to host a workshop of representatives from geothermal producers, the oil and gas industry, logging service companies, electronics manufacturers, the U.S. Geological Survey, other national laboratories, and the academic community. This workshop established the program's goals and priorities and initiated a set of interactions among the interested parties that has continued up to the present time. We also set up an industry based advisory panel that has met about twice a year to review the program and to make recommendations for future emphasis.

We are now completing our geothermal instrumentation program. We have met the goal of establishing 275° C. electronics technology. We have verified the performance of prototype instruments in actual geothermal field tests with industry participants—Union Geothermal and Gearhart Industries. We have stimulated the commercial refinement and production of the electronics—through Teledyne Philbrick in Massachusetts and Harris Semiconductors in Florida. A new firm, Quartex Incorporated of Utah, was granted the rights by DOE to produce a new product, a double-ended quartz tuning fork, that was developed under our geothermal program. We are now completing the R&D activities, publishing a sourcebook on high temperature electronics and planning a large conference to review the achievements and stimulate industries to develop their own inventions and applications.

Throughout the program we actively promoted technology transfer. By means of many publications, meetings, and presentations we made contact with many firms and individuals interested in high temperature electronics, not only for geothermal, but for other applications as well (such as enhanced oil recovery, deep gas explorations, jet engines, nuclear power and space exploration).

An example of this type of exchange was a joint project with firms who needed to make borehole measurements to monitor steam injection for enhanced oil recovery. We made sure the DOE participants in this area knew of our work and we also adapted one of our prototype instruments so that it could be evaluated in this application.

Another example exists in the natural gas industry. As the search for gas is made into deeper regions of the earth, higher temperatures are encountered. For example, at 18,000 feet the temperature is typically over 150° C. In order to develop logging tools for this application, two large logging service companies, Schlumberger and Gearhart Industries, have used the technology being discussed to stimulate their investments in new people and facilities to continue research and development along similar lines.

Small business has also benefitted from this effort. Two new firms, Hot Hole Tools in New Mexico and Thermodurics in California, indicate they are making use of our R&D to provide new products and services.

Jet engine manufacturers met with us to review their needs for high temperature instruments. After we reviewed their detailed designs, we acquainted them with the new technology and suggested specific components and circuit designs. This interaction led to our working with the Naval Research Laboratory to develop high

temperature integrated circuits for naval aircraft. These integrated circuits are now being commercially developed by Harris Semiconductor.

In the area of nuclear energy, our geothermal electronics work provided synergism with other in-house research into temperature and radiation hardened semiconductors. In addition, we now have some new interactions with researchers at Oak Ridge who need high temperature instruments for nuclear power reactor monitors.

Another example of technology transfer is in our interactions with NASA and JPL for their application to exploring Venus where the atmosphere is above 300° C and surface temperature approaches 475° C. We have met and reviewed respective needs and determined ways to apply the new technical developments.

The cumulative results of the above developments and technology transfer activities will be displayed at the "Showcase for Technology" in Albuquerque on October 28 and 29, 1981. A detailed review will be presented at a High Temperature Electronics and Instrumentation Conference in Houston, Texas, on December 7 and 8, 1981. In addition to speakers from Sandia, many of the above mentioned organizations will present their own developments and products at this conference.

The above activities and accomplishments illustrate that technology transfer was not only an integral part of this energy R&D program but also its major end product.

Senator SCHMITT. OK. Dr. Cox?

Dr. Cox. I see my cohorts have brought other things, and I brought transparencies.

Senator SCHMITT. We wouldn't know we were in a technical briefing without them.

Dr. Cox. Senator, members of the subcommittee, ladies and gentlemen, it's a pleasure to be here.

Today I'd like to discuss explosives technology in New Mexico and how it might be applied to the private sector. We believe that that technology can be applied directly to solve nonmilitary problems. As you know, we have a history of successful explosives work here in New Mexico, and most of the technology that's been discussed thus far in this State really started with the start of Los Alamos Laboratory in the forties. We have also the necessary high technology resources to do that within the State of New Mexico, and our scientists and engineers are committed to transferring their knowledge to the private sector.

One example where we have been very successful in working on the military problems was a problem we were given within the military of finding safer explosives. This was for military application, primarily nuclear weapons. Within the State we can divide explosives technology into synthesis, formulation, evaluation—I can't forget that, that's my group—and applications. I think very unique in New Mexico is the way in which these four major groups can interact with each other. There are feedback mechanisms where someone comes up with a product or a particular component and we can test it right there at Los Alamos, we can send it in to Sandia, we can send it to Socorro to be tested. We have very strong information techniques to really test and then send back that information to see if it can't be perfected.

In our example here, the synthesis people took a compound that was invented or discovered 100 years ago but there was no way of actually making it, it hadn't been evaluated; we didn't know too much about it. The compound was TATB, triaminotrinitrobenzene. It happens to be a fairly insensitive, it doesn't go off very easily, explosive.

It was not in the form, however, for military application. So the evaluators, the formulators, the safety people got together. We

added inert materials so that the compound could be machined and molded to meet the very high military specifications for that product. And as a result, we have now something called PBX-9502, which stands for plastic bonded explosives. And to this point, it appears that all tests have indicated that there is no possibility of accidental detonation of that explosive. So we were very successful and very proud of that. That's done at Los Alamos.

Senator SCHMITT. When you say accidental, it won't detonate in a fire or under impact?

Dr. COX. Right.

Senator SCHMITT. It will only detonate when you tell it to detonate?

Dr. COX. Exactly.

Additionally, we have the high technology resources to really put explosives technology into the private sector. We have not only the space, which is very important often in looking at explosives technology—you have to have a big area to blow things up in, and we have that here, which is so small matter. That's sometimes very difficult to do in highly populated areas.

We also have instrumentation needed, and probably most important, we have the people, the resource people—the scientists, the technicians, and the engineers—to do the work. They are centralized at Los Alamos, Sandia, the Air Force Weapons Laboratory, New Mexico Institute of Mining and Technology, and UNM.

Finally, there is our commitment. And I think sometimes because we were developed, especially at Los Alamos and at Sandia, as a highly military organization where we were under a great deal of secrecy, it's hard to see the application of our technology to anything other than the military. The Showcase is giving us a great opportunity to look at what we could do within the private sector.

So our people are demonstrating a great deal of enthusiasm, and we can see that enthusiam within the Showcase. For the first time, I think some of these people are being challenged to say, What can we do for the private sector? And they're really going for it. At this point we have 15 different exhibits just within explosives technology alone. We expect over 70 scientists and engineers alone in explosives technology to be able to come and talk to R. & D. leaders. Five of our exhibits will demonstrate controlled use of high explosives.

Senator SCHMITT. Dynamically?

Dr. COX. Yes.

And we'll have oral presentations where people will be overviewing the applications of HE and advanced developments expected.

Senator SCHMITT. Do we have a safety engineer on the floor?

Dr. COX. At the Showcase or right here now? Certainly. We have the fire department involved.

One particular application that is just in the exploratory stage, again demonstrating that the engineers and scientists want to transfer their technology, is an exploratory project as Sandia to investigate the effect of shock waves on various materials. The object of the game is to take an explosive and detonate it. That creates a shock wave which we can then send into a material. The

shock wave impacting on the material changes its properties, and it can become a new material.

At this point we have only preliminary results. But these preliminary results are exciting. We can increase the chemical reactivity of refractory materials and we can possibly increase the catalytic effectiveness of varied catalysts. This is at the infancy stage of work and to see results may take 10 or 20 years, but it's very exciting.

Senator SCHMITT. Are you familiar with the explosives high pressure research that's been done within the experimental geology community which is consistent with those two things you had at the bottom? That's how the major research for a long time was done where you're talking about high temperature, very high pressure mantle, submantle-type pressure.

Dr. Cox. Right. I'm not—to an extent.

Senator SCHMITT. There's an area of literature you might look at; it's been around for 20 years.

Dr. Cox. Another area we're developing at Los Alamos is the chemical synthesis of thermally stable explosives. Many conventional explosives melt, go to pieces, do not perform well under the high temperatures, such as are needed for geothermal boreholes. We have what we believe is one of the most thermally stable high explosives ever developed, and it was indeed created—many explosives were invented 100 years ago in Germany and Europe, but here we have one that was developed at Los Alamos. It has a lot of potential.

Finally, another new way of looking at high explosives, instead of taking one molecule and letting it detonate, we can mix different molecules togther that may not be detonable separately but together will form an explosive mixture. This, again, is in its infancy, but there's a great deal of potential here. We can tailor the mixture so we can fracture rock any way we might want to. This has application for the military as well; one may use ammonium nitrate factories to produce explosives as well as fertilizer.

So I'm really excited about our involvement in the Showcase. I think our people throughout the State are beginning, at the instigation of the Showcase, to look at areas where we might apply our technology and not to be thinking about only the military application but to look beyond that, as well.

[The statement follows:]

STATEMENT OF DR. MARGARET M. COX, PH. D., DETONATION RESEARCH SCIENTIST, LOS ALAMOS NATIONAL LABORATORY

Mr. Chairman: It is an honor to submit this statement for the written record of this hearing.

EXPLOSIVES TECHNOLOGY

The science of explosives has a long and successful history in this country. Beginning with the establishment of Los Alamos National Laboratory during World War II, the scientists and engineers in New Mexico initiated the effort to augment an engineering, rules-of-thumb science, by systematically investigating the fundamental nature of explosives. As a result, the work done at Los Alamos National Laboratory, Sandia National Laboratories, the Air Force Weapons Laboratory, New Mexico Institute of Mining and Technology, and the University of New Mexico represents a large fraction of the total body of knowledge that is known today as explosives technology. Within New Mexico we have the capability to pursue basic questions that relate to the understanding of detonation physics and chemistry, and

to apply this new knowledge toward the development of explosives with improved safety and more precise detonation performance.

I begin with a survey of the state-wide expertise in explosives technology. While most of this effort is a continuation of the military application of explosives, I will discuss the transfer of this technology to industrial users developing civilian applications.

EXPERTISE IN HIGH EXPLOSIVES TECHNOLOGY

The work we do here in New Mexico with high explosives may be divided into four areas: synthesis, evaluation, formulation, and application. The first two areas represent basic research in the field, the other two are applied research areas.

Within the synthesis area scientists study the molecular structure of explosive compounds. Such investigations provide information which allows us to synthesize new explosive compounds with properties satisfying specific requirements. For example, new explosives developed here in New Mexico are able to perform well and safely under conditions of high temperature. An applied area of our synthetic work includes the development of more efficient synthetic routes to ensure the economic feasibility of manufacturing large quantities of specific explosive compounds.

The study of the physics of the explosion process constitutes evaluation. In order to understand and predict how an explosive will behave under a variety of conditions, we incorporate sophisticated experimental, analytical and numerical techniques. Additionally, explosives must be tested by firing them under controlled conditions. Specific experimental designs are used to test performance characteristics such as detonation pressure or detonation-wave velocity. With strong computer support, these results provide the detailed knowledge of performance that aid the synthesizers and formulators to improve their products. These same tools are also used to examine the safe conditions under which an explosive may be stored, transported or used.

In formulation activities, explosive mixtures are studied to determine the moderating or intensifying effects that several components may have upon one another. A notable advance has been the use of plasticizers which permit us to make precisely shaped explosives, which have applications for both military and civilian use.

Engineers and scientists in New Mexico are studying various applications of high explosives. One area of particular interest is the use of explosives to aid deep-well oil and gas extraction processes. Sometimes our evaluative tests point to novel applications of explosives, and such tests stimulate further applications research.

EXPLOSIVES TECHNOLOGY TRANSFER

Material modification with explosives

Scientists at Sandia National Laboratories have started an exploratory program to investigate the effects of introducing an explosively generated shock wave into a material. While this program is still in its infancy, two important results have been obtained. The first involves shocking powdered materials that will later be used in high temperature and high pressure environments. These shocked materials have a greater chemical reactivity which may permit processing them at significantly lower temperatures than would be possible with the unshocked powders. This potential break-through may point to new directions for the manufacturing of refactory materials.

The second result that appears to have industrial application involves shocking catalytic materials. Preliminary studies show that a particular catalyst, TiO_2, is 10,000 times more effective after being shocked than the unshocked catalyst. Such exploratory work is an example of a new technological approach to an old problem.

Thermally stable explosives

Scientists at Los Alamos National Laboratory are able to synthesize explosive compounds which are melt-resistant in the high temperature environments found in some deep underground wells. Such geothermal heating can be a problem if conventional explosives are used. Solving this type of problem involves the engineering of complex explosives devices. Not only must the main charge be thermally stable, but the more sensitive initiating systems must also be able to withstand the high temperatures involved. We are developing a system that incorporates a commercially available firing unit with out thermally stable shaped charges. This system has been successfully tested at temperatures of 300°C to depths of 13,000 feet.

SHOWCASE FOR TECHNOLOGY

Through our work we have shown that a greater understanding of the properties and behavior of a high explosive allows us to fabricate and manufacture safe and efficient devices that will perform useful work.

The Showcase for Technology presents us with an important opportunity to discuss our results and ideas with corporate Research and Development Leaders.

By establishing personal contracts with these corporate managers, we expect to be better able to transfer our present knowledge to both the public and private sector. Our goal is to use the framework of contacts developed at the Showcase to facilitate communication among the similarly oriented R. & D. sectors to answer adequately questions and solve the problems facing society today.

Senator SCHMITT. Thank you very much.

Dr. Holm?

Dr. HOLM. We have a projector here that I had better get set up.

Senator SCHMITT. Would you like me to go ahead and ask some questions while you set up?

Dr. Cox, is there a coordination of the explosives technology R. & D. at the laboratories? Is there some official coordinating committee?

Dr. COX. We have coordinating committees with respect to project managers.

Senator SCHMITT. Individual projects?

Dr. COX. Right.

Senator SCHMITT. Do you have any overall?

Dr. COX. Most of those project managers are oriented toward the military application. There are some areas within the geological framework where we try to combine resources, but it's mostly the project management level.

Senator SCHMITT. Do you want to proceed, Dr. Holm, or do you want to wait for your slides?

Dr. HOLM. I can go ahead, and if the projector works, fine; if not, we can ad-lib it.

I'd like to thank you for the opportunity to talk to you a little bit about the technology with which I'm familiar. Most of it occurred during the approximate 8 years that I was U.S. Department of Agriculture and Los Alamos liaison and program manager of the USDA project; however, since last December, I've been more associated with flow cytometry, and I'll be able to talk a little bit about that.

I'd like to summarize my remarks by saying that there will be three examples of technology and its transfer that I'd like to talk about, two of which were quite successful, the third one is not completely successful yet, and I'll deal most of the time with that particular one that is not particularly successful.

The first that I would like to talk about is the flow cytometry, but since the projector isn't quite ready, I'll talk about a device for the treatment for cancer eye in cattle. It was developed in the Meson Physics Division. You put the probe right on the eyeball of the animal; you pull the trigger; and after the eyeball surface gets up to about 50° C., the thermocouple in this probe here senses the temperature and the beep sounds about once a second. And after 30 seconds, the treatment is over. With one treatment on a small tumor, one gets about a 90 percent cure rate. With larger tumors that have to be given more than one treatment, the rate of cure is about 98 percent with the second treatment. [Slides shown.]

The slide shows an actual treatment on the eyeball of an animal with this little device, and the next picture will show before and after treatment of cancer eye. Cancer eye is an important problem in livestock, particularly in the higher altitudes, because it's caused by ultraviolet light.

Another use of this device is for treating fungus diseases. They hadn't anticipated it would work for that, but it's quite effective and is now the preferred treatment by some people in Colorado who were working with us. Modifications of this device are being used for treatment of human cancers, and they are readying one of the units right now for shipping to China. People from China indicated that surgical treatment of brain tumors is not effective. They said that any improvement at all that this device might give would be a major improvement. So they plan to put the probes directly into the brain tissue left after surgery and see if they can get a better cure rate.

I think I'll show another application here of a technology that is a spinoff of this but is fundamentally quite different. This is using radiofrequency heating to cause shrinkage of the eyeball to cause permanent changes in the eye. The slide shows some experiments being done with monkeys, and the next one shows some of the equipment. It requires a cooling of the eyeball as opposed to just application of heat so you don't do damage to the part of the eyeball that you don't want to have heated. The treatment seems to be effective for something like a year and is very encouraging for a nonsurgical procedure.

The technology was developed to the point where companies just had to copy our design and that's what they have done. A picture that I have with me shows equipment from the five companies that are manufacturing these, and they look very much just like this one of ours I have in my hand.

Senator SCHMITT. How did you justify going that far?

Dr. HOLM. Because until we took it that far, it wasn't a convenient thing to use. It was a laboratory device and people couldn't relate to it. Also the investment to finish the job was not very much money. We could show that it would work and was a very useful device. The next generation for the treatment of human cancers will not be carried quite that far.

This slide illustrates flow cytometry. I'll try to be very quick about it. The blue is a laser light that comes into a flow cell. Single cells, one at a time, go through that laser beam and cause florescence, and then if the particular cell or chromosome is of interest, the drop containing the cell is charged by the charging plates that are green. The charged droplet is deflected by the deflection plates a little lower. This instrument is very important currently in genetic research because we can tie fluorescent flags to particular molecules and thereby sort cells or single chromosomes and speed things up considerably.

We have played a passive role in the transfer of this technology to industry. The papers we wrote were read and people from commercial enterprises could see the importance of it; they sent their people to our lab and learned what we were doing, went back and built commercial instruments. Some of our people were consultants to them and some people left tha lab to work with the companies

or started some of them up. It has worked out very well. It's doing now about $6 million a year and, I believe, is a very successful. Case of technology transfer.

Senator SCHMITT. Was there a patent transfer involved, licensing?

Dr. HOLM. There was a licensing of the cell sorting, and that was the only part we had a patent on.

Senator SCHMITT. Which one?

Dr. HOLM. The lower part where you actually charge a droplet and sort it. And the follow that developed that left the laboratry and started up a company.

Senator SCHMITT. And he has exclusive license or waiver on the patent?

Dr. HOLM. It's waivered, yes.

Senator SCHMITT. Where did that company locate?

Dr. HOLM. It started in Los Alamos, N. Mex., and then it moved to the main Coulter Electronics factory in Florida.

I'll try to show you a case that is an entirely different problem, and this is electronic identification. It was developed originally for the Department of Agriculture.

This slide shows a hand held version of it. There's a little electronic transpowder implanted under the animal's skin. This little device that I have in my hand with the power supply that does not show here can interrogate the transpowder at about a 10-foot distance. It will read the identity and temperature of the animal. The transpowder in the animal has no battery itself. With a full power interrogator unit you can determine the identity of the animal to a range of up to 30 feet. The next slide shows the sort of electronics that is currently in the transpowder, and you can get a scale from the hand. The main reason for the size of the transpowder is that the antenna needs to be large enough to extract energy out of the beam and power up the electronics because it has no battery.

Now, I'd like to talk a little bit about why the technology has not been successfully transferred. There are a number of reasons. The most important one is similar to the one mentioned with the insulin pump, namely, that there had to be quite a bit of research done to show that the concept was good, a viable thing in the marketplace. And we have not been able to carry it that far.

In fact, it is similar to a football game and we're on the 1-inch line and they've called the game. It's a very sad situation and that's why I'm not working in the project anymore. We ran out of money to carry it the next step.

Some of the reasons why private industry wouldn't pick it up are that there was a large investment, it was high risk, and there was a long time between the investment of the money and the return. The companies were also quite concerned with governmental red tape. The things that you've been addressing here, I think, are very positive signs toward solving those particular problems. The companies were not willing to get into a new market that was multidisciplinary, in the agriculture and electronics, because they didn't have the experience in those areas?

Let me just give you an example of one company that is well known in the electronics business. We had a representative come to the lab trying to interest the company in marketing this device and

he said, "We build a chip, sell it for 25 cents, and they put this in a $20,000 bull; somehow there is a problem with this bull, he dies, and we get sued for $20,000 on a 25 cent chip with implied warranty. We don't want to touch it." The agricultural people have been implanting things in animals for years and not worrying about it, but they didn't have that experience in electronics and are not willing to get into it.

So the real problem is, we have not been able to carry this development to the point where it is far enough along to where industry can either copy it or know that there is an established market for it. We feel that there is a huge market for this.

Senator SCHMITT. Have you worked with Mexico State on this?

Dr. HOLM. Yes, and we have one of our systems down there operating. It's weighing cattle and it's been working out in a trailer under very harsh conditions, as you might imagine.

Senator SCHMITT. You're talking about this?

Dr. HOLM. Not that particular system you saw here, that is a portable unit; but there is the one with all the bells and whistles.

Senator SCHMITT. Well, is the Mexican State willing to be as a sort of a demonstration project for this?

Dr. HOLM. Yes, but we haven't got the money to do all of the demonstration needed, and they haven't gotten the funds themselves to do it. That's our problem. The USDA has backed out now, for reasons I'm not sure of; they have not told me what the problems were, and it's very sad. We've run out of money just short of the goal.

Senator SCHMITT. Now, is that it for your testimony?

Dr. HOLM. Yes.

Senator SCHMITT. In the cattle eye device, what are the terms you have in your agreement with the companes that are producing it? You say five companies are producing it?

Dr. HOLM. Yes.

Senator SCHMITT. Are they paying a royalty?

Dr. HOLM. I don't believe so at this time, because the market is fairly small.

Senator SCHMITT. And do they have an exclusive license?

Dr. HOLM. No.

Senator SCHMITT. Of course.

Dr. HOLM. So it's not exclusive.

Senator SCHMITT. So you just license them?

Dr. HOLM. Yes.

[The statement follows:]

STATEMENT OF DR. DALE M. HOLM, LOS ALAMOS NATIONAL LABORATORY

Mr. Chairman and Members of the Subcommittee: It is an honor to appear before you representing the Los Alamos National Laboratory and to discuss the experiences that I have had in technology transfer.

Most of the things that I will discuss are based upon personal experiences while I headed an agricultural bioscience group from 1972 through 1980. However, I will also discuss some of the technology transfer from the group with which I am currently associated. I would like to make some general comments and then follow them with some specific examples with which I am familiar.

GENERAL COMMENTS

The following is a list of some of the items I think are important and which bear on the success of technology transfer.

Problems and Requirements. There seem to be at least four ways of developing a technology and transferring it to industry. No one of them seems to be the best way in all cases. The military has been using the so called, "fly off", for many years in which the government funds all or part of the development of a particular product by more then one potential supplier and the prototypes are compared on a one-for-one basis. The purchase is made of the best one. This seems to work rather well but requires a technology to be fairly well developed, it is rather expensive and is applicable only if there is a fairly large market or critical requirement.

A second method is to bring industry in when an idea is still new and considerable development needs to take place but there is an obvious commercial involvement that is needed. This was certainly the case in nuclear power and geothermal power and was being attempted in coal gasification.

The third method is to complete the development of a full system ready for marketing such that it just had to be copied. This is the way the National Laboratories build nuclear weapons and the way the Cancer Eye treatment device was developed that I will be describing later.

The fourth method is for the developers of an idea to quit the laboratory and start a new company. An attempt at this was made for electronic identification of animals and it has been somewhat successful after a faulting start.

We must recognize the proper time to apply each of these ways to transfer technology and create the atmosphere to encourage the operation through trust and cooperation. The system must be flexible enough to follow the specific needs. It seems that technology transfer works best if (1) it is perceived as a low risk by the perspective company, (2) it is currently in the line of business now, (3) there will be a short turn around time between investment and return, (4) there is an obvious market where the company will be there first, or (5) they will have exclusive rights to an important patent.

I found a great deal of resistance to becoming involved if the particular product was outside the company's established expertise. For example, in the case of electronic identification of animals, electronics manufacturing companies were very hesitant to become involved with an agricultural market and agricultural companies were hesitant to get involved with electronics manufacturing. Each of them wanted the total operation under their control if they were to be involved.

I have been quite dissappointed with the timidity that I have observed in industry. Certainly, they must make a profit to stay in business but it has appeared to me that this timidity is directily proportional to the resources of a company. I have heard comments from representatives of large companies that indicated they do not fund really innovative research. Their mode of operation was to buy up a company that had been organized to promote a specific new product. The small companies had the interest, flexibility, and vigor in pursuing the development and were willing to take the high risks associated with it. Frequently, the company was started by people who were intimately involved in the development of the idea. Therefore, the National Laboratories should accept the role of high risk projects and ones with a long lead time. They should then find the appropriate industrial group to work with

Commitment and Reward. I have observed a rather strong historically entrenched adversary relationship between government and industry. It seems to have its origin in the role of government in regulation and protection. I believe that it is having a very negative effect on creativity and our national position in the marketplace as compared to countries such as Germany and Japan where it appears that government works better with industry. I believe it is important to establish official policy that states the importance of cooperation between industry and government, but this must be followed by implementation that rewards cooperation. At present there is not a good reward system for the scientists or potential users. For example, scientists are professionally judged by their contributions to the scientific literature so the extensive amount of effort sometimes needed for technology transfer does not normally have much professional rewards. On the other hand many businessmen have expressed to me their reluctance to get involved with government because of what they considered excessive control demanded by government. Unless the obstacles to cooperation by both the developers and the potential users are addressed and surmounted, technology transfer will be less effective than it could be.

Public Relations. If a prospective user of a technology does not know about it, he cannot develop an effective interest. Technical people tend to think of public relations as brainwashing and trying to sell something that is not wanted. It is not thought to be a proper function of a scientist. Certainly there is an aspect of high pressure selling in much of the advertising that goes on, but it is extremely important to give this part of the process its due consideration. One must make contact with the prospective users and frequently, we don't know who they are. The Commerce Business Daily reaches a particular group of aggressive business people, but I

found that Entrepreneur magazine was the most effective instrument for identifying a broad range of potentially interested parties. Science News was second and the Los Alamos National Laboratory Mini-Reviews were third. After that, it was hard to identify which were the most effective since we had articles in many trade journals. The movies that we made and were widely shown were important to describe the idea to a potentially interested person and helped to sell the ideas, but I do not consider them the best medium for identifying potential users.

Funds. Generally, the sponsoring agency of research has little motivation for transferring that technlogy to industry so there is a shortage of funds to perform technology transfer. We have noted that specifically, in the case of electronic identification.

SOME SPECIFIC EXAMPLES

Cancer Eye. This is an electronic device with a probe that is put on a tumor to heat it up. The tumor is more sensitive to heat than normal tissue. It has proven highly effective in field testing.

Cancer eye in cattle is an important economic disease in New Mexico ($20 million/yr nationwide). I have been told by a cattle breeder that there is a 5 percent new case incidence in many cattle herds and in the older brood animals, the incidence will reach a rate as high as 80 percent over eight years of age.

Many aspects of this particular development have gone extremely well and it might be considered a "text book" example of the third method previously mentioned of technology transfer. However, I would like to take this opportunity to make a point on the nurturing of innovative research. I think it is important because it is the environment in the embryonic stage that is critical if there is to be a flow of new ideas that later become technology.

The cancer eye treatment device was developed primarily by an electrical engineer, Mr. Doss, and his associates and is the result of his persistent efforts to apply his knowledge in electronics to an area of science (medicine) where he had no credentials. It came about because he was associated with a practical applications group working on pion cancer treatment. He wondered if one could treat tumors by heating them above body temperature. After discovering that it worked on mice, he found a small amount of literature indicating that others had found this to be true also. Mr. Doss developed a radio frequency (Diathermy type) heating device. His experiments, in collaboration with the University of New Mexico Medical School, were written up in one of the Los Alamos internal news media, and a physicist friend of his told him about the possible application on human eye tumors. Cancer eye in cattle was suggested as a model for human eye tumors. In looking for cattle to treat, he made contact with Dr. Larry Foster at New Mexico State University and through him, arranged to treat animals on the Jicarilla Indian Reservation. He later performed tests on a number of herds within New Mexico.

Upon learning of his work with small animals and his interest in cancer eye in cattle, we tried to secure US Department of Agriculture funding for the work but they considered it, "Too far out" so we were unsuccessful. However, Mr. Doss had the freedom and support necessary to initiate the relatively low level of work to follow his interesting lead and develop the instrument and perform field tests. Without this freedom to follow up a new and interesting idea, this development would not have taken place. I urge you as a Senate Subcommittee to formally acknowledge this and allow agencies the discretion to follow up good ideas that are outside of their formal mission. I am well aware of the possible criticism made under the name of "duplication of effort" but I think it is important to recognize that good ideas on a particular subject do not come to only those who are given the responsibility to have them. I would like to emphasize this even further to state that I know personally of many instances in which this type of phenomenon has been demonstrated in the past.

Also, if Mr. Doss had been required to do a literature survey, become medically educated, write a proposal, have it reviewed and wait for funding, he would have been "turned off" and spent his time on other things because in the embryonic stage, he was not sure that it was a good idea. So we need to recognize the fragility of new ideas in the early stages of their development and not kill them with formalism. This is particularly true when a person is moving into an area where they do not have the credentials or experience.

I supported the work of Mr. Doss emotionally, if not financially and I believe we have had a rather close relationship since he became involved in the cancer eye project. As soon as it looked like he was ready for transferring the technology to industry, I started working more closely with him in the writing of the mini-review and in producing the movie because these were the media that I would use in my contacts with the cattle industry. It was through my contacts with the cattle

industry that I got Mr. Doss together with the two companies who are now producing most of these units commercially. They merely added this item to their product line and we estimate their sales to be about $800,000 to date. The companies that tried to make this item a main product line have not been very successful because the market was too small and they lacked the marketing channels. Mr. Doss had taken the development far enough to where the potential manufacturers just had to copy his designs and that is essentially what five companies did. I have a picture here with me that shows his unit and some of the commercial units. You can see the striking similarity between them. In 1978, this development was considered by Industrial Research Magazine to be one of the 100 most significant technical developments in the year. The work is essentially complete at Los Alamos with only an occasional letter to interested parties and a small amount of activities keeping up with the current results being obtained.

I think it is important to mention the spinoffs that this project has had. There have been requests for demonstration units from many foreign countries. Most of the time, Mr. Doss has been successful at getting commercial companies to provide the demonstration units. Currently, he has a demonstration unit in Argentina. We understand that cancer eye treatment devices are being developed for manufacturing in both Australia and New Zealand. Adaptations of this equipment are currently being used for human cancer treatment as well as for the treatment of pink eye and fungus infections. A demonstration unit for human cancer treatment is in Peru and a second unit is being readied for shipping to the People's Republic of China.

An evolutionary development that is quite different from the cancer eye treatment device is currently being tested for corneal reshaping of congenital eye deformations.

Electronic Identification. This is an electronic tag designed to be placed under the skin of an animal. It can be energized and read remotely to give the animal's identification and temperature. The concept has many non-agricultural applications, for example inventory control, shipping, personnel badges, credit cards, and electronic license plates.

We have carried the project through all of the high risk phase, but because of funding restrictions, we were unable to carry to carry it to a truly successful completion where industry was either intimately involved with us in the development or could just copy what we had done. There is one company currently building electronic identifiers that are somewhat similar to ours but they have decided to go after the inventory market rather than the animal market because of the lower risks and the potentially larger return. We do not have the funds to develop the fully integrated chip that is the key to widespread commercialization. We have not been successful in getting private industry to take the necessary risk in developing the chip. The reasons the companies have given me for not becoming involved is that the market is not well established, it is too long a time between a substantial cost investment and the return because of the field testing required.

A number of companies would have been interested in a cost plus contract which we were unable to enter into. It has grieved me considerably to have had to stop my involvement in this work when we were essentially right at the goal line and just needed a few more inches to get across. We had developed, I believe, considerable livestock industry support and it was proven technically sound. It was also selected by Industrial Research Magazine as one of the 100 most important technical developments in 1978.

Flow Cytometry. Flow cytometry consists of passing biological preparations usually cells or chromosomes, one at a time through a forcused laser beam and observing the fluorescence of tagged molecules. These tags indicate the quantitative relationship between biological components. This equipment is proving to be very useful in the clinical laboratories as well as providing quantitative information for basic biology.

Our Laboratory developed the concept of sorting single cells by forming droplets which contain no more than one cell and then putting a charge on the droplet and sorting it by electrical deflection. We wrote many papers in the scientific literature. These were monitored by companies in the field and they sent their representatives to our Laboratory and went back to their manufacturing facilities and developed instruments they thought appropriate. We also built specific instruments for the National Cancer Institute. We have used it for detecting tuberculosis and distinguishing between strains of Newcastle disease in chickens.

I believe that this is a successful example of technology transfer and that our Laboratory had a positive and influential role in its development. However, the impetus came primarily from industry and we played a somewhat passive, yet supportive role by agreeing to let their representatives come to our Laboratory and see what we had built as well as talk with them. There are three commercial

companies now doing about 6 million dollars a year in business. One would hope that the manufacturing industries would pick up new ideas like this for all governmentally developed technology. I think that the reason this worked out quite well is that there was an obvious clinical application and the industry kept up on the literature.

We think that the development is near maturity but we expect about 4 or 5 more years before we can see an end of our development work. Our current effort is primarily at improving the sensitivities so that we can indentify individual chromosones and then can sort them. This will be useful in what is commonly called, "Genetic Engineering" and there are also many applications in immunology that we think will be served by this instrumentation.

Crop Surveillance. This item is quite different from all of the other items that I have been discussing since it is primarily an idea at this time with a little bit of data to support it. The possible ramifications of it seem to be very great. The concept is to shine short pulses of visible light on crops and observe the plant flourescence and backscattered light as a function of time. From this information we think it may be possible to identify some crops and deduce their health.

I'd like to point out that this is an active system contrast to the passive system that is currently being used by NASA and USDA in which they look primarily at infrared radiation and crop predictions are made by a combination of historical records, multi-spectral scanning and a fair amount of luck. The active system that we are proposing is different because it involves actual interrogation of the plants. In essence, you can ask the plant specific questions rather than listen to what they want to say. The particular questions that we would like to ask the plants are: What kind of a plant are you? What stage of development are you in? What is your yield likely to be? Are you sick and if so, what disease do you have? Implicit in those questions are fertility and water status. We might not be able to get definitive answers on these questions, but I believe there is a reasonable probability that we can get meaningful answers to them. The very limited amount of data that I have at present indicates that we probably can do some crop discrimination, that we might be able to detect certain diseases by their flourescence pattern, and that we can probably tell something about how well the plants are watered.

This project is in the embryonic stage where we don't know it it is viable or not. To really test these ideas out, it looks like we need some fairly expensive equipment. If we are lucky, in the next six weeks I will be able to get enough data to convince a funding agency to thoroughly evaluate the potential. If not, the idea will lay fallow for a few more years. If things go well, what I would propose is to carry the project far enough to where a firm firm evaluation could be made of the potential. If that turned out to be positive, then I would write the appropriate scientific papers as well as start the public relations activities to see if there was commercial interest. Then I would hope to bring commercial interests in as soon as they were ready. I can currently visualize two possible commercial spin-offs of this. One would be an aircraft flyable system that would monitor commercial crops for disease and drought conditions and also work under contract to the government for monitoring public lands. I believe the effects of gypsy moths and pine beetles might be monitored with this type of a system. The other applications are the obvious national and international needs of monitoring worldwide crops from satellites. I should point out that my calculations indicate that it would push the technology to the limit to do this from satellite. I am not prepared to say, for sure, that we could do it from satellite even if the concept is sound.

Senator SCHMITT. What about, Dr. Veneruso, the terms to the companies using the high temperature electronics technology?

Dr. VENERUSO. Again, the emphasis that we placed on it was to get these people involved from the very beginning, so we avoided——

Senator SCHMITT. You just spin it off?

Dr. VENERUSO. Exactly, we spun off technology as we went along. If we filed patent disclosures, industry was interested in picking those up. They petitioned the DOE—there are rules and regulations governing that—and a patent waiver was granted with march-in rights so if the company involved does not perform in making that product available, the Government can march in and take those rights of license back.

Senator SCHMITT. Have you had to do that?

Dr. VENERUSO. No, because the companies are pursuing it with vigor.

Senator SCHMITT. Now, Dr. Cox, are you and Dr. Veneruso coordinating in any way geothermal technology? I can see you explode your high temperature, insensitive explosive electronically, right?

Dr. Cox. Right.

Senator SCHMITT. Have you worked together at all to be able to put some of the tailored explosives downhole so that you can tailor the fracture patterns in high temperature rocks and at the same time explode those same explosives?

Dr. Cox. This is the first time we met, so personally we have not. We have had some dealings where we have done some of that. We took a Sandia explosive, HNB, and used that in England to do some granite work with a thermally stable insensitive explosive developed at Los Alamos, plus TATB, and it was very successful.

Senator SCHMITT. Can you see an application between the two?

Dr. VENERUSO. I might mention that, although Dr. Cox and I have just met, there is a committee made up of people from both Los Alamos and Sandia involved in this work and we made the instrumentation we're working with available to them. Independent of that, Union Oil Co. came to us with a problem is that they wanted to fracture a well in the Geysers field north of San Francisco. And they said: "Could you lower an explosives package for us with a detonator 8,000 feet deep in steam at 260° C?" and we said: "Sure, we'd be happy to do it." And we developed a little package to do that. The field test is scheduled for this fall.

Senator SCHMITT. That's conventional explosives, though?

Dr. VENERUSO. It's a new explosive that a company called Rocket Research in Washington State has developed.

Senator SCHMITT. How does that relate to what you've been doing? It is a different development?

Dr. Cox. Our people in the geothermal division are going to be a part of that project.

Senator SCHMITT. No, but the explosive.

Dr. Cox. That was not developed at Los Alamos. It's a salt compound, before it melts it's not detonable. It only will detonate when melted at those high temperatures.

Senator SCHMITT. Dr. Cox, where do you see most of the applications for shock producted materials?

Dr. Cox. At the present time, Du Pont Co. is making diamonds, 50 percent conversion rate of graphite to diamonds, using explosively directed shock waves.

Senator SCHMITT. What's the domestic source of graphite, do you know?

Dr. Cox. No.

Dr. HOLM. I think it's natural gas, because it's so pure. I'm pretty sure it is.

Dr. Cox. I think the catalysis work that they've done has great promise, and I think, if we can get catalysts to be more effective it has a lot of potential.

Senator SCHMITT. Has that been done under their industrial research and development?

Dr. Cox. At Sandia?

Senator SCHMITT. The Du Pont process is an outgrowth of that?

Dr. COX. No. I think it was a Du Pont endeavor.

Senator SCHMITT. Is there a lot of parallel explosive related research in industry right now?

Dr. COX. I don't see very much at all. We see Du Pont not getting to any great extent into explosives anymore, and they were the founding company in explosives work and are moving further and further away from it.

Senator SCHMITT. Why wouldn't there be an interest in your insensitive explosives?

Dr. COX. To some extent they're expensive to make. Now, the new thermally stable one was designed to be made in a cost-effective manner—it's a two-step manufacturing process; I think it has a lot of potential. The other aspect is, how much do we need it? How much are people willing to spend to get something that might perform better? I think the results in the end—if we have developed machines that would take out rock that are 20 pounds in weight, perhaps we can develop new machines that will take them out when they're a lot smaller. But sometimes a new technology means you have to have other transfer too. Retooling may be expensive.

Senator SCHMITT. Has explosive forming of metals lost some of the glamour it seemed to have a few years ago?

Dr. COX. Certainly not in our work, in weapon work. We do some of that. We're not greatly involved in it at this point.

Senator SCHMITT. What about industry, is there much going on out there?

Dr. COX. We hear of it—I don't known. We need that transfer of technology information. It seems available, but I don't know if it's——

Senator SCHMITT. Dr. Veneruso, do these high temperature electronics require significant capital investment before they can be manufactured by, say, a firm that otherwise would have the capability for manufacturing ordinary electronics systems?

Dr. VENERUSO. Again, that was one of the questions we asked ourselves when we started in 1975, and because we had industry advisers, we tailored the work, we did so that industries that normally make what's called hybrid thick film electronic circuits have all of the equipment and tooling necessary to do the high temperature job.

What's different about the high temperature circuitry is that we're using inks that are formulated for high temperature and bonding of wires. We did the metallurgy, wire pull testing along with all of the arts and crafts of making a hybrid circuit using the conventional kinds of equipment that are available now. Two big companies, Schlumberger and Gearhart, are now using this kind of technology, whereas 5 years ago they were not. And that represents a substantial investment on their part. And again, it's a thing we could measure and say: "That is a measure of our success." This is the technology transfer that was the goal of our program.

Senator SCHMITT. So as a final question, could each of you give the subcommittee the one or two or three major items that you think are obstacles to successful transfer? You've had successes, you see a great potential, you've had successes and failures.

Dr. Veneruso, why don't you start. What is the biggest obstacles right now to successful tranfer of technology from Government to private industry?

Dr. VENERUSO. Well, certainly there are obstacles, but I would say the biggest obstacle or hindrance is not listening. By that I mean, we didn't known much about the geology, geophysics, and the electronics of well logging when we started. Our expertise is in other areas. So for us to go ahead and build these logging tools we need to listen and understand what industry needed. Why wasn't industry already doing this? The answers to these questions would be different for every different program. It would be different for the biomedical field; it would be different for the community of oil and gas producers and geophysics.

Senator SCHMITT. I think you've over categorized it. It's really a case by case——

Dr. VENERUSO. Exactly, case by case. And the obstacles or the difficulties I encountered in our program certainly may be completely different in other programs.

Now, all the things mentioned today, streamlining the patent question, that would help a lot. When we got involved with the little quartz crystal pressure guage, we really couldn't talk to anybody on the outside because DOE was making an assessment whether or not to go ahead with the patent. So anybody who came to us and said: "Hey, tell us about that neat quartz work you guys are doing," we just couldn't talk about it until DOE made the assessment.

Senator SCHMITT. You're kidding me.

Dr. VENERUSO. No.

Senator SCHMITT. How could DOE prevent you from talking about something like that if it was not a classified item?

Dr. VENERUSO. Because one we make a patent disclosure and sent that to DOE, then DOE has to make an assessment. And until that assessment is made and a patent filed for, we were told not to discuss the details of the work and not to publish it, because prior publication is one of the factors in patent law. I'm not a lawyer.

Dr. HOLM. It gives them longer time to file, too, until it's public knowledge. As long as they keep it close, it's not public knowledge.

Senator SCHMITT. But under what authority can you keep something from public knowledge if it's nonclassified? I mean, keep something classified when it's nonclassified?

Dr. HOLM. No, it's not a classification question.

Senator SCHMITT. I understand that. That's why I think that——

Dr. HOLM. It gives the bureaucrats longer time.

Senator SCHMITT. Yes, but under what authority can you do that?

Dr. VENERUSO. Again, I'm not a patent lawyer, but I think the reason——

Senator SCHMITT. It would make logical sense from DOE's point of view, but I'm surprised they can get away with that. I'm surprised you can sit there and say, I'm sorry, I can't talk to you about this. We're trying to see whether we want to patent it or not.

Dr. HOLM. I've been told the same thing.

Dr. VENERUSO. I could find out for you.

Senator SCHMITT. Well, if you want to add some comments on that, we'd appreciate it.

Dr. VENERUSO. As I understand it, not being a patent lawyer, it's that a determination needs to be made to protect the taxpayers' interest. That's as much as I understand, but it is a hindrance, an obstacle in terms of time that we encounter.

Senator SCHMITT. OK. Dr. Cox, what do you think is the major obstacle?

Dr. COX. I would say in explosives research at this point one thing we need is long term, consistent financial support; within Los Alamos, Sandia, and within the university systems as well, fluctuations in the amount of money that flows through for various projects can fluctuate not only from year to year but within the year. The capital needs for many of our projects require support for anywhere from 5 to 20 years to follow through on a project to see if it's to go from creation to a product that could be sold to the private sector.

Another area is that I think industry still fails to recognize that basic research is absolutely critical and that the knowledge we get does pay off, and that's a lot of what we do in detonation work. But we can create, as a result of our research, safe explosives through the knowledge we're obtaining. I think we're going to start to make major breakthroughs in the next 10 to 20 years.

And in our particular area, explosives have been around for 200, 300 years, so people, I think in general, say, well, we know everything there is to know about explosives; when in fact it is really a basic science as far as really understanding what's going on.

Then finally, our peope need to know that they have marketable ideas. Many of us have lived in institutions which have classification rules, with regard to publishing our results. Even if you think that somebody might be able to use your idea, it takes encouragement for us to say, hey, there's a market out there for some of our ideas, let's be creative, and there might be payoff. And we need to be thinking along some of those more outrageous ways.

To think of putting a shock wave into a material and changing its properties, I think is unique, but it's not something one might have just thought of when you see people blasting dirt.

Senator SCHMITT. OK. Dr. Holm, my guess is that one of the problems you would suggest is getting over that threshold, the financial threshold, of financial commercialization?

Dr. HOLM. Yes.

Senator SCHMITT. How do you go from generally adequate, or at least semiadequate funding for research to actually getting a product into an assembly line?

Dr. HOLM. Yes. Well, let me give you a little background on that from, let's say, the USDA's point of view. They were interested in being able to identify animals from a disease point of view. The livestock industry was only a little bit interested in that, because they saw it as a way for the Federal Government to get the internal revenue-type data on them. So there was, effectively, a conflict of interest.

So that's why we put temperature measurement in it, because we figured this would make the user want to use it; but this put the USDA in a very bad position, because they were keeping that

temperature measuring in for the wrong reasons, effectively because they weren't interested, this was a consumer type of interest and they left it was not proper for them to support the livestock industry needs.

So this brings me up to a point that I think is very important and that is this historical antagonism that has been addressed today between industry and the Government. And somehow we've got to address that, because that relates to the rewards that industry gets for becoming involved, and it also relates to the scientists who are involved too, the reward system. Because generally, the reward system does not reward the scientist who gets involved in technology transfer, because we're not set up for that. "Scientists," don't get involved in peddling. I happened to be a peddler when I was a kid, and I sold cooking utensils. And it's been very valuable, because now I'm trying to peddle science.

Senator SCHMITT. Thank you, panel. We'll move on to our final witness.

Bill Lehmann, sorry to keep you waiting, but the Secretary sort of appeared prematurely.

STATEMENT OF DR. WILLIAM LEHMANN, CODIRECTOR, TECHNICAL INNOVATION CENTER, UNIVERSITY OF NEW MEXICO

Dr. LEHMANN. I'm real glad to get this opportunity to come here and talk about a very exciting concept and one that I think has a lot of potential, but also one that has its problems. And I'm not going to let you get off the hook without being aware that there are some problems.

I'd like to describe a technology innovation center that we're trying to put together here in New Mexico in the context of technology transfer, and then I'm going to give you some specific examples of that, what we're trying to do in that center and some of the developments, both favorable and unfavorable, that we're going to have to try and work with to make this center a success.

If you look at technology in this country, it's primarily been developed with large organizations over the past 40 years. The individual idea is very important in getting something started, but then the support it takes in terms of laboratories and shops and computer services requires a fairly large organization, and we've had these in the Federal Government, in industry, and in some universities.

The people in these large organizations usually have a pretty good idea why they are pursuing the line of technology, so that when it's successful they have a pretty good strategy on how to employ it in their corporation or in the agency; and in fact, technology transfer has been tremendously successful internally to the large organization.

I think your flying up to the Moon was an example of that where the technologies that NASA and others developed were all transferred and put together into the Apollo program. The Department of Defense has been very effective in turning technology to use in military systems. The DOE laboratories have been very effective in transferring their technology into military systems. So we've got a lot of successes in the technology transfer.

Now, technology transfer, however, is not always a desired objective. It's not always viewed as something to be sought for. In particular, if you're a corporation, you don't want your competition to get the benefits of that technology, you want to transfer that internally. The DOD certainly wanted to transfer its technology to military systems and they didn't want the Soviets to get it. And the DOD laboratories very clearly, the old DOD and the old ADC, very clearly wanted to restrict the transfer of nuclear technology.

Another factor, no one was ever promoted for transferring technology to a competitor or to somebody who didn't make a difference. So technology transfer is not always viewed as a desirable end goal.

There's a another barrier to technology transfer, and that's that big organizations have big inertia and new innovations are not always welcome, because you're going to put somebody out of business and you're going to change the way things are done. There are hundreds of examples where the innovative individual felt that he had to leave a large organization to pursue his own idea and, in fact, he left and the successes of these individuals are legendary, but they're relatively few in number.

The concept of a technology innovation center, which I'll describe in a moment, does offer these individuals who are in large organizations that would like to go off on their own, it does offer them the opportunity and the means to make that jump.

I'd like to add that a few major industries have had policies that when a bright individual with an entrepreneurial instinct developed something in their corporation that did not fit in with their product line, the corporation would help this individual make the transition to his own company, giving him advice and even financial support in return for a stake in that company, and they encouraged that kind of spinoff.

Senator SCHMITT. Is General Electric an example of that?

Dr. LEHMANN. Yes; General Electric Research Lab is the one I was thinking of. I think that probably was under the influence of Art Bueche, who was a very farsighted individual.

Senator SCHMITT. Still is.

Dr. LEHMANN. Still is, right. But there are others. There are others in addition to General Electric.

Within the university world, you mentioned Route 128, high technology activities in the Greater Boston area, and Silicon Valley. Those are almost universally associated with MIT and Stanford, two universities which had a very conscious policy of encouraging their faculty to get involved with profitmaking business and even—and also would encourage their faculty to go off on their own and try for this initiation of a successful business. That they were successful is attested by the health of their communities.

A group of us a few years ago started thinking, Gee, it would be fun to try and put something similar to that together here in New Mexico. We have one of the finest national laboratory and test organization complexes in the world here in New Mexico. We have a fine set of universities; we have some local industry. All the ingredients seem to be there.

I think you'll recall we came to you to talk over these ideas in 1978 and you encouraged us to explore these, and we did. And then

in 1980 we kicked it off and said. All right, we're going to build a New Mexico Technology Innovation Center.

The objective was to take the good technical ideas and come up and transfer those and help those become a new business or help existing businesses to expand into those areas. The top leadership at UNM encouraged this exploration but they encouraged it in cooperation with the other universities in the State. They released Ray Radosevich part-time to work on this technology innovation center and we got tentative commitments from the other universities that they'd like to be a part of this with support from various industrial groups here in New Mexico.

We developed a concept of a statewide network. There would be major centers at New Mexico State, New Mexico Tech, UNM, which have a high involvement in technology; and there would be liaison offices at Highland University, western New Mexico and eastern New Mexico universities, which don't have that much involvement in technology but do have some very good assets.

The objective of this network, which would also involve private businesses around the State, would be to provide individual entrepreneurs or inventors with the technical and business know-how in areas that they themselves lack, to provide them with access to laboratory and test facilities and equipment, shops and computer support, legal regulatory advice, and even seed money to help them get going—all the things they would need in order to transfer a good technical idea to commercial practice.

In January of 1971, Professor Radosevich at the University of New Mexico offered a course in technological entrepreneurship, which was sort of a trial run of what a technology innovation center would do. He had about 18 students, and he had teams of these students working with each of four different clients with high technology ideas.

The students worked with them on marketing and financial and business aspects that would pertain to their program and wound up with a draft business plan for these people that they might pursue; received a small grant from the Four Corners Regional Commission which provided for some seed money for testing, for materials, and for various kinds of services in return for stock in the corporation.

One good example was a senior scientist at an industrial laboratory in Albuquerque who decided they weren't going to go into the business of nondestructive testing material. He had worked in this area and he developed some electromagnetic acoustic transducers which would let you take a radar-like picture of the flaws inside of a metal casting or forging or a pipe or a well by ultrasonic waves.

Normally you have to coat the material, coat the casting or the pipe with a goop or gel or liquid and then put your transducer on there. He came up with some techniques which said, I don't have to put that goop there. That immediately let him look at high temperature applications or running a transducer down through an underground pipeline looking at the wells or going over rails at high speeds—had many desirable, attractive possibilities.

This team of students and he worked together, and they put together a business plan, looking at the marketing and the financ-

ing and the organization and the production and all those different aspects, and that one looks like it's going to be a success.

Out of the four clients, two are very great interest, one of them involving the heat pipes from Los Alamos, a great interest to venture capital and they'll probably get picked up by some private venture capital people. One is still under proof of principal now and one other one is looking at the different markets because it didn't seem financially feasible.

We took the concept and in 1981 bills were introduced in the New Mexico Legislature to provide support for a statewide center. They failed to pass. The National Science Foundation made a decision——

Senator SCHMITT. Bill, I will say for the record at that point, and you need not comment, but it was one of the sadder points in the history of the operation of State government to find everybody in Santa Fe in full agreement, everybody, Governor and all the legislature, and everybody in full agreement that this ought to be done, but they couldn't agree on who got credit for it so it wasn't done. And it's that simple. I hope this next session of the legislature will show us a little more responsible leadership than that; although, the legislature is not the only one to blame, the entire operation there just fell apart on this particular issue.

Dr. LEHMANN. Well, perhaps we didn't do all our homework and didn't get everything adequately presented to them. We're going to try again.

Senator SCHMITT. I certainly hope you will.

Dr. LEHMANN. We're sort of looking toward the national level. We felt that the National Science Foundation's support of technology innovation centers, and they supported half a dozen at different universities across the country, which have been, almost without exception have been strong successes, and the product of those centers have returned more in taxes to the U.S. Treasury than the appropriations from the NSF were, and they also created jobs and were a success in every sense of the word. We were optimistic on that, and then NSF decided to get out of the technology innovation support business.

We looked at the Stevenson-Wydler Act, and that looked great and seems like it was a stillborn, nothing happened, or at least has yet to happen. We've looked at venture capital. Venture capital shows a lot of interest in the products of the technology innovation center. That's a primary interaction, but they're not going to support a secondary interaction for the center itself.

So we have a problem, then, of finding support. We plan to go back to the legislature, and we're also investigating private foundations. I'd also like to investigate the possibility that out of the Stevenson-Wydler Act, section 11, that we might get some support out of Federal laboratories for such a center as this.

I'd like to throw a couple criticisms at the Federal Government. It's not clear that the policies are consistent. NASA, by law and by charter, I might add, pursues technology transfer very aggressively, while NSF gets out of it and Stevenson-Wydler is put on the shelf. It's not consistent that you would have one set of rules pertaining to one organization and different groups behaving totally differently.

The DOD and Department of Energy programs do not—for technology transfer do not appear to be that well formulated or articulated at this time. We've had a lot of old signals from the Federal level that have been stopped and reversed, and the new ones are not yet clear. State level involvements are not yet widely understood, and while the private sector may be developed for existing centers to succeed, it doesn't appear promising for the establishment of new centers.

I'd like to go back and point out that there are some problems within the Government laboratories. Without a program, there's not much incentive for individuals in Government laboratories to aggressively pursue technology transfer; and more than that, conflict of interest provisions, which are very proper, seem to prohibit individuals, scientists, and engineers from laboratories, from pursuing technology innovations that might lead to their personal financial benefit ultimately; they're inhibited from pursuing those on Government time. In a sense, that's proper, and yet in another sense it's like MIT and Stanford, there's got to be some way to encourage people but in some framework to move out and get in the technology innovation.

Well, policies at the national level appear to have reduced the chances for the success of the establishment of the Technical Innovation Center in New Mexico, but I think we're optimists out here. We're going to try and find a way to make that happen. We're seeking those alternatives that we can, different ways of skinning the cat so we can get that thing going and get New Mexico a New Mexico Technical Innovation Center by the time you're down on these hearings a year from now.

Senator SCHMITT. Bill, I appreciate your testimony.

What approaches and what responses have there been to those approaches to say, major ongoing industrial concerns in the State, or particularly in the Albuquerque area, ones that might not realize any benefit from it but as a general service to the community might invest in the center, at least the seed money?

Dr. LEHMANN. First of all, Jack, this is substantially a two-man effort, part time, with some support from the university community and encouragement from a lot of people, including yourself. We've met with some interest from the utilities in the State, particularly PNM. We have gotten generic kind of endorsement from the industries here, but fundamentally the industries, plants here, General Electric and other industries here in the Albuquerque, N. Mex., area, they don't make that kind of policy. Those are made at corporate headquarters.

The laboratories, the national laboratories—Sandia, Los Alamos, White Sands, Physical Sciences Lab, Weapons Lab—they are governed by policies determined by their agencies in Washington. And they're supportive in principle, but they also have some problems in encouraging their people to go off, spinoff, and innovate. And that's a policy that should be addressed at the national level and find mechanisms to enable people in the laboratories to make a transition to private entrepreneurship without paying undue advantage over their competitors. And I think that is something that might be a good topic to ask for the Federal Consortium of Laboratories to investigate and come up with some policies on.

Senator SCHMITT. Are there any models, successful entities, that operate on the model that you see here in New Mexico, other than the NSF centers?

Dr. LEHMANN. Yes. Only one I know of other than NSF, Cal Tech has a, not a center but a mechanism for bringing outsiders into contact with experts within any technical community. They've been pretty successful with that. The others have pretty much been the NSF supported ones, but the University of Utah has been an outstanding example. The former dean of engineering there put a great deal of personal effort into this and was a very successful entrepreneur himself, and that with the NSF support has been, probably, the outstanding one after you get away from the Silicon Valley and Route 128 complexes.

The situation is different here, because as you pointed out, over a billion dollars a year goes into the Los Alamos, Sandia Weapons Lab, White Sands complexes, and you have to deal with them on a different basis than you would with aerospace industries in Los Angeles or Utah, Salt Lake City.

Senator SCHMITT. Bill, is your little part-time group of two or three people going to make any specific effort to sell the concept in conjunction with the Showcase for Technology? Is there an option there?

Dr. LEHMANN. No, not specifically. We participated in the Showcase in the planning for it but the Tech Innovation Center is primarily of interest to the local area in developing. It's not going to be of interest to some outside businesses that might want to come in; in fact, it might wind up in competition for them. I think maybe we missed the boat on that. Certainly, the Tech Innovation Center can help existing businesses by putting them in contact with experts in fields they don't have that expertise on now. But no, we don't have a role in the Showcase.

Senator SCHMITT. Let's think about that. There may be a possibility or two.

[The statement follows:]

STATEMENT OF DR. WILLIAM LEHMANN, CODIRECTOR, TECHNICAL INNOVATION CENTER, UNIVERSITY OF NEW MEXICO

Senator Schmitt, thank you for the opportunity to describe our efforts to establish a Technical Innovation Center in New Mexico and the impact we believe this Center will have on technology transfer. I am a Visiting Professor in Nuclear Engineering and Management at the University of New Mexico, involved in the effort to build such a center. For the past fifteen years I served as a policy level official and a Director of Air Force Research and Development activities, where I was directly involved in several elements of technology transfer. I also serve as a Director-at-Large of the American Institute of Aeronautics and Astronautics, a professional society that is strongly involved in technology transfer.

In my remarks today I will describe where a Technical Innovation Center fits within the overall technology transfer process, the unique environment for technology transfer in New Mexico, the proposed New Mexico Technical Innovation Center, and recent developments and policy issues on the national scene that impact upon the chances of such a Center for success.

Technology developed in the U.S. over the past 40 years has mainly had its origins in federal laboratories, in the laboratories of major industrial corporations, and in the universities. The largest sources of funding have been the many federal agencies that need R&D for their missions, or whose mission is R&D itself. Ideas are always generated in the mind of an individual, but the means to develop the idea have been found only in the larger organizations. These large organizations usually pursued technology base activities against some recognized need, so that when a technology development was successful they had a good idea as to where they would use it. Technology transfer within the organization, or with their partners in gov-

ernment, industry or the universities, thus became an objective of the corporate R&D strategy. In this primary goal, our institutions have done very well.

Technology transfer is not always a desired objective. While a corporation clearly wants to reap the benefits of its technology developments internally, it does not want those benefits to go to its competitors. While the DOD and NASA laboratories want their developments to get into the aerospace industry, the DOE and its predecessor AEC clearly wished to control nuclear technology very carefully, often retaining it within a small complex. Thus all the incentives for technology transfer were for internal technology transfer, and transfer outside the organization has generally been strongly discouraged, and no one ever got promoted for doing good things for the competition.

Technology transfer is not always a desired objective for another reason. Big organizations inherently have big inertia, and new innovations are not always welcome. There are hundreds of examples where the innovative individual felt he had to leave the larger organization for his idea to grow, and leave he did. The successes are legendary, and there is almost universal agreement that our country is stronger in all ways because of that individual initiative. But the successes are few, and it is there that the Technical Innovation Centers can serve in a significant way. Usually the separation is not encouraged by the parent, but this is not always the case. A few of the more forward looking corporations will assist their innovators in establishing their ventures when they have reached the corporate decision not to pursue it. They in effect become a Technical Innovation Center in their corporate world.

Within government, a few agencies and individuals recognized the national benefits to be derived by the transfer of technology to the general commercial sector. NASA has aggressively sought to transfer aerospace technology, the NSF has explored different ways to bring the fruits of their basic research into the commercial sector, and the Congress has supported various measures such as the recent revisions in patent law and the Stephenson-Wydler Act, which you co-sponsored, Senator Schmitt. Nevertheless, conflict-of-interest policies and mission orientation serve to effectively limit entrepreneurship or technology transfer from government labs. This is particularly important in New Mexico, with its strong national laboratories. Within the university world, faculty are strongly encouraged to transfer technology through their research, consulting, and of course their teaching activities. With a few notable exceptions, individual entrepreneurship or corporation involvement other than consulting is not encouraged. But those exceptions are notable, and a few universities do stand out as the birth places of new high technology companies. Among others, the greater-Boston high-technology complex is always associated with MIT, "Silicon Vally" with Stanford, and Salt Lake City with the University of Utah. These universities have encouraged the involvement of their faculty with profit-making industry as a matter of policy, and indeed encouraged many in the establishment of their own companies. Some have become textbook example of high technology successes.

The National Science Foundation sought to enhance technology transfer to the private sector some 8 or 10 years ago through the establishment of Technology Innovation Centers at a half-dozen selected universities. NSF funding enabled these Centers to provide needed material and support and knowledge to technical people who had a promising idea. In return for these resources, the centers received equity positions in the business, and a few Centers are close to becoming self-supporting. The successful companies have produced jobs in the private sector, and overall have returned more in taxes to the U.S. Treasury than the original NSF fundings. The Stephenson-Wydler Act, appeared to provide a broader base for Technology Innovation Centers. Here in New Mexico, the Four Corners Regional Commission provided some small but critical support to our fledgling Center. In 1980, a small group of individuals in New Mexico decided to attempt to start a New Mexico Technology Innovation Center. The presence of the major national laboratories and test centers in the state and their great record of the generation of new technology provides a tremendous asset. The commercialization of technologies out of these laboratories has been relatively small, even considering the classified nature of much of their work. The growth of existing companies and the establishment of new ones would benefit those laboratories and centers by providing them with a broader base for technical support, as well as create the job opportunities need in the area.

The top leadership in the University of New Mexico encouraged exploration of a center that would involve all the universities in the state, and provided released time for one professor. With the tentative commitment from those other universities and industrial groups, the concept of a state-wide network was developed. This network would provide individuals or existing companies with know-how in the technical and business areas they lacked, access to laboratory and test facilities and equipment, shop and computer support, legal and regulatory advice, and seed

money, to invest or loan to pay for these services. Subcenters would be established at New Mexico State University, New Mexico Tech, and the Unviersity of New Mexico, the three universities strongly involved in technical work. Liasion offices would be established at Highlands, Western New Mexico and Eastern New Mexico Universities, which have a smaller involvement in the technical arena. Procedures would be established for use of unique equipment in the federal laboratories on a non-interference basis and in accordance with their governing regulations. Existing businesses which could help in translating a high-technology idea into commercial realization would be incorporated into a formal network.

In January 1981, Professor Radosevich of the University of New Mexico offered a course in Technological Entrepreneurship. As a part of this course, students from engineering and management formed teams that worked with four client technical entrepreneurs on an experimental basis. Together they considered technical feasibility, design, engineering, test, production, marketing, financing, patent and legal, regulatory, management, and all other technical and business factors as appropriate and as needed. The result was a draft business plan for each of the clients, which was publically presented as a student project to key people from the technical and business communities. A small grant from the Four Corners Regional Commission provided funds for materials, testing and services to the clients in exchange for stock. Of the four, two are now proceding towards commercial financing, one is in product development, and one is pursuing further feasibility studies.

As example is illustrative. One scientist client had done extensive research on electromagnetic acoustic transducers which detect flaws in materials by use of ultrasonic waves. Ultrasonic waves have been used for some time to obtain a radar-like image of castings, forgings, extrusions, etc. that would detect flaws and imperfections. In the past, however, all procedures had required the use of a liquid or a gel that was painted on the article to be tested. The client's invention allowed him to do these inspections without the liquid or gel interface. This opens up new potential applications. High temperature pipe can be inspected. Underground pipelines can be checked for flaws in their welds. Rails or tubing can be inspected at much higher rates.

In this case, the client needed little technical expertise. He did, however, need marketing and business planning help. This, plus test and legal service were what he gained from the association.

In 1981, bills were introduced into both houses of the New Mexico legislature to provide support for a state-wide center but failed to carry. A decision by the National Science Foundation under guidance from the new administration resulted in cancellation of their Technology Innovation Center program. The Stephenson-Wydler Act was not funded. Venture capital in the private sector looks very promising for clients, but we see no mechanism and little possibility that this will enable a New Mexico TIC to get established. (No funding support from the DOD or DOE laboratories appears possible within present agency or OMB guidelines.) Plans are underway to propose full funding to the New Mexico Legislature next year, and we are investigating private foundation support.

It is not clear if consistent policies have been set for all agencies in the federal sector. NASA, by charter, pursues technology transfer aggressively while NSF gets out and Stephenson-Wydler is put on the shelf. DOD and DOE programs do not appear well formulated or articulated at this time. The old signals from the federal level have been reversed and new ones are not yet clear, if they exist. State level involvements are not yet widely understood, and while the private sector may be developed enough for existing centers, it does not appear a promising source for establishment of new centers.

Thus, changes in policy at the national level appear to have reduced the chances for the establishment of a Technical Innovation Center in New Mexico. This would negatively affect the kind of technology transfer that a TIC could foster. In line with what we perceive to be broad national philosophy, we are seeking alternative means to achieve the benefits that a New Mexico Technology Innovation Center can produce.

Senator SCHMITT. I think we better close off the hearing at this point.

I want to thank all the witnesses and everyone else who assisted in these hearings today.

Unless you have some suggestion, we'll adjourn the hearing and continue this process at a future date.

[Whereupon, at 1:20 p.m., the above-entitled hearing was concluded.]

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